WARRING

STUNT CONTROL LINE FLYING

MARSHALL

STUNT CONTROL-LINE FLYING

STUNT
CONTROL-LINE FLYING

by

R. H. WARRING

LONDON
PERCIVAL MARSHALL & CO. LTD.

Printed by ELECTRICAL PRESS LTD., Cordwallis Works, Maidenhead, Berks
and published by PERCIVAL MARSHALL & CO. LTD.,
23 Great Queen Street, London, W.C.2

CONTENTS

CHAPTER I

INTRODUCTION

THE full potentialities of a control-line model are realised in the specialised design capable of a full range of aerobatics, within the limits of the scheme. The one essential requirement to maintain control is that the control lines themselves remain taut enough to transmit movement of the control handle to corresponding movement of the elevators. Thus with the model constrained to fly in a circle round the pilot, any manoeuvre in the pitching or "up and down" plane is theoretically possible and can, in fact, be performed in practice; provided the design itself is inherently capable of such manoeuvres and there is ample thrust to maintain flying speed.

A short history of the development of the control-line model has already been given in Book I, so there is no need here to elaborate on this. Book I also describes in detail the various control systems and the basic principles of control-line flight.

The actual definition of a stunt model is a little difficult to lay down. A stunt model should be capable of all or nearly all the possible control-line manoeuvres as listed later on. The limiting factor is more often the pilot than the model itself, for advanced stunt work does demand considerable skill, which is gained only by constant practice. The luck element is less apparent than in other branches of model flying and the resulting performance a pretty true reflection of the pilot's ability in this particular sphere.

Straightforward control-line flying is quite properly classed as a sporting pastime. The degree of skill required to fly a control-line model in ordinary circuits is not high and almost any average individual can become proficient at it with very little practice. Given a true stunt model, stunt flying is then almost entirely a test of the pilot's skill and ability. The emphasis is, in fact, truly on the pilot. The other specialised branch of control-line flying—speed models—is dependent upon the design of the model (and particularly the motor-propeller combination) rather than flying skill, and the two classes have become widely divergent.

Control-line flying started in this country with sports type models, which were quickly developed into stunt control-liners. The first control-line contest ever to be held here was for aerobatics and was held in the winter of 1947. Here for the first time the winner was able to demonstrate consecutive loops and this manoeuvre did, in fact, form the basis of the best flight pattern. But subsequent development has been so rapid that the loop is now considered a very elementary manoeuvre and the whole of the possible range of manoeuvres listed on the original Society of Model Aeronautical Engineers' stunt schedule had been achieved by quite a number of individuals before the end of 1948.

One of the most surprising features has been the fact that very small models with relatively low-powered motors have proved as effective as larger machines with very powerful 10 c.c. motors. This in direct contradiction to the original belief that the small control-liner would never make a stunt machine. The smaller models have, in fact, one very great advantage over their larger counterparts (apart from lower initial cost) in that they are infinitely more robust. That is to say, a small stunt model can be crashed frequently with very little damage resulting—and crashes are quite frequent with advanced stunt work, particularly when learning. A crash with a large stunt model usually calls for an extensive rebuilding, or even writing off the model as useless for further flying.

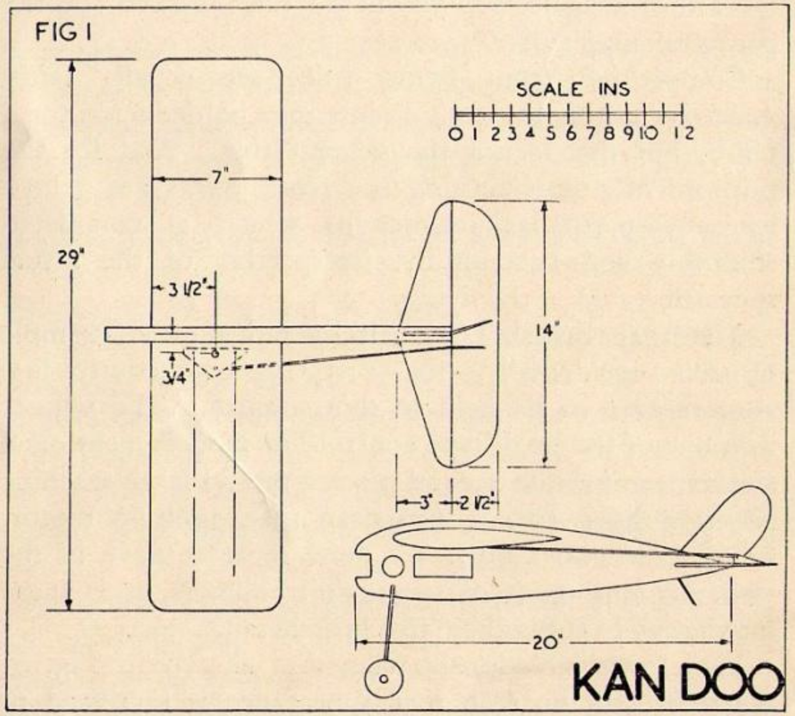
From the point of view of thrilling flying—both as regards the pilot and that of the spectators—the larger model has no rival. But whether or not the additional expense and greater risk of serious damage is worth it is a matter of individual choice. For purely contest flying, where the sole object is to complete a chosen flight pattern and gain the maximum points possible, the small model has many advantages. Being slower it is far more docile and allows the pilot more time to think and act; and frequently if the machine does actually crash during its competition attempt it can be got airborne again well within the time allowed and the pattern completed.

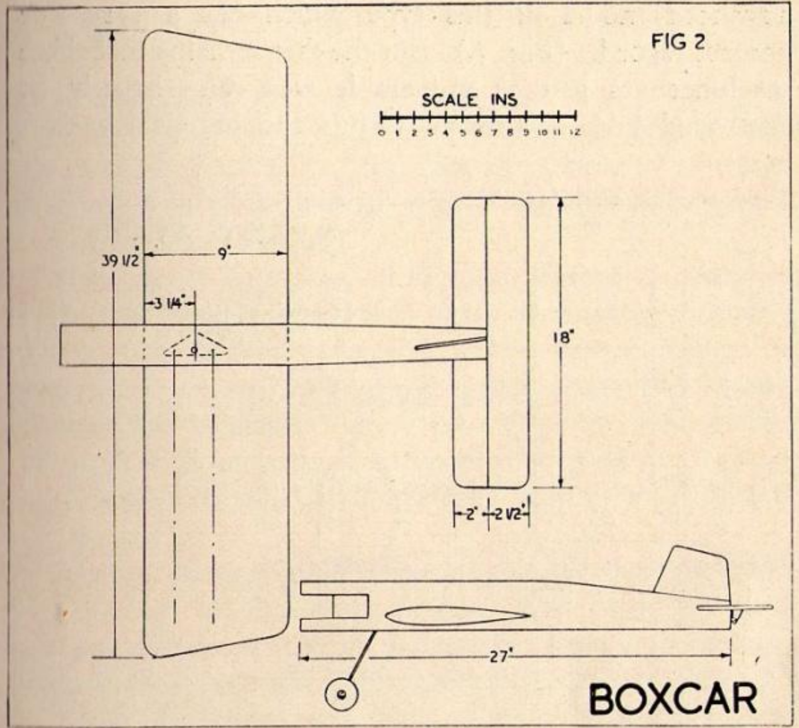
Competitive stunt flying rules are usually fairly generous in this respect. Points may be deducted for a crash, but this is not the general rule. And for the purpose of points scoring the same points are gained for any particular manoeuvre which is completed smoothly and successfully, irrespective of the actual spectacle value of the flying.

The 1948 British Nationals offered a good example of this—incidentally, the first National control-line contest ever to be held in this country. The winner flew one of the small-type control-line models mentioned above, beating into second place a typical large machine powered by a 10 c.c. American spark-ignition motor. Since these two models are quite representative of the two different types of stunt control liners, it is quite instructive to study them in a little detail.

Pete Cock's Nationals winner is shown in Fig. 1, where it will be seen that appearance is sacrificed to provide a simple and essentially practical machine. A typical British diesel motor—the "E-D Competition Special" of 2 c.c. capacity—is used, fitted with a stunt tank. During the course of its competition flights—ten minutes allowed each competitor to complete his chosen flight pattern—it crashed several times, but the only damage resulting was a broken propeller which was readily changed and flying continued.

The second place machine was Dennis Allen's "Boxcar," powered by a 10 c.c. "Super Cylone" motor—see Fig. 2. Here again this is essentially a "utility" design with no attempt made to effect a pleasing appearance, but the basic difference is that had this machine crashed during its competition flight it would have





been "written-off" and quite unable to continue after minor repairs. This was, in fact, demonstrated when a similar machine did crash in the course of consecutive loops.

The designer of the "Boxcar" frankly admits that the model is made as simple as possible since he regards each machine as "expendable." Crashes are inevitable and after a bad crash the machine is simply scrapped, useful parts salvaged and rebuilt into another machine.

Not all large models are similar in this respect. Many of them, and particularly the American stunt machines, are more elaborate and often very pleasing in appearance. "Smart Alec" is an outstanding example of an advanced model of this type which has a very fine contest record. (Fig. 3.) But the fact remains that these machines are just as vulnerable and can virtually be destroyed in a bad crash. Thus the practical answer

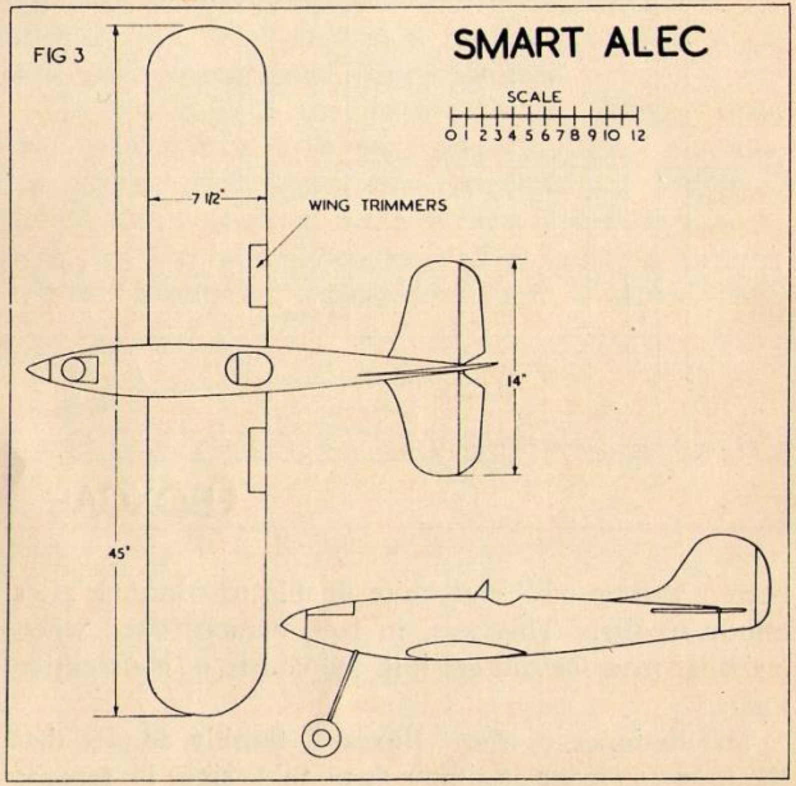


FIG 3

is that the large and more elaborate machine really is only a proposition when the pilot concerned is quite proficient at sunt control-line flying.

The logical approach to stunt control-line flying would, therefore, appear to be to start with a simple, low-powered and robust machine on which the pilot

can learn all the manoeuvres in the flight pattern. The crashes which result during the learning stage need not prove serious, most of them, in fact, leading to nothing worse than a broken propeller. When fully proficient in the art of *flying*, then is the time to consider a large, powerful machine with " eye-appeal " as well as performance.

Many stunt fliers may, in fact, be content to continue with the smaller models. For one thing, suitable motors are readily obtainable. The present range of British diesel and glow-plug motors provides many outstanding examples very well suited for such work. Being British motors, too, replacement parts of repairs are attended to readily should the motor get damaged in any way.

Almost without exception, the suitable high-powered motors are of American origin. Not only are such motors difficult to get at the present time, but replacement parts or servicing are practically non-existent.

Those modellers with little or no control-line experience can start right in with a small stunt model, first learning to fly on it and then going on to practising more advanced manoeuvres with the same machine, working right up to contest standard if ambitious in that direction. Design requirements for a successful stunt model are not stringent and all the necessary data are given in subsequent chapters. Starting in this manner is far more likely to give satisfactory results than attempting a large machine for an initial attempt, for under such circumstances the life of such a model will be relatively short.

Many modellers prefer to start with a kit model before going on to their own designs, and this is sound practice. There are quite a number of highly successful stunt models available in kit form, these having been well developed and any snags ironed out before being put into production. Such a kit model, with adequate power, can be capable of holding its own against the more specialised designs.

The psychological effect of flying a small model for stunt "training" is quite marked. Small motors are relatively quiet and, by comparison with large 10 c.c. motors, appear innocuous. The models themselves fly at only moderate speed—between 35 and 45 m.p.h. —which to the pilot in the centre (and turning with the model) seems very slow indeed. The pull on the lines is usually quite light.

For the very first flights, the control movement can be stopped right down—say, about 10 deg. up movement and 5 deg. down movement—Fig 4—and the full elevator range used as soon as the tyro pilot has learned to fly the machine straight and level. When it comes to attempting manoeuvres—and the loop is generally the starting point at which most pilots hesitate—there is far less strain on the pilot than with a larger, noisy machine.

It is not uncommon for a comparative novice to

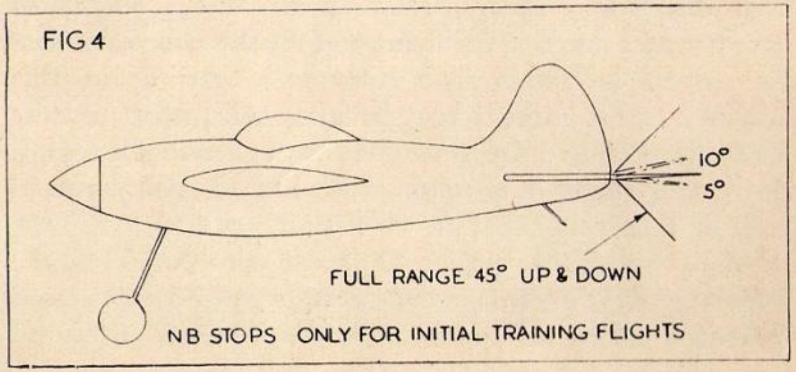


FIG 4

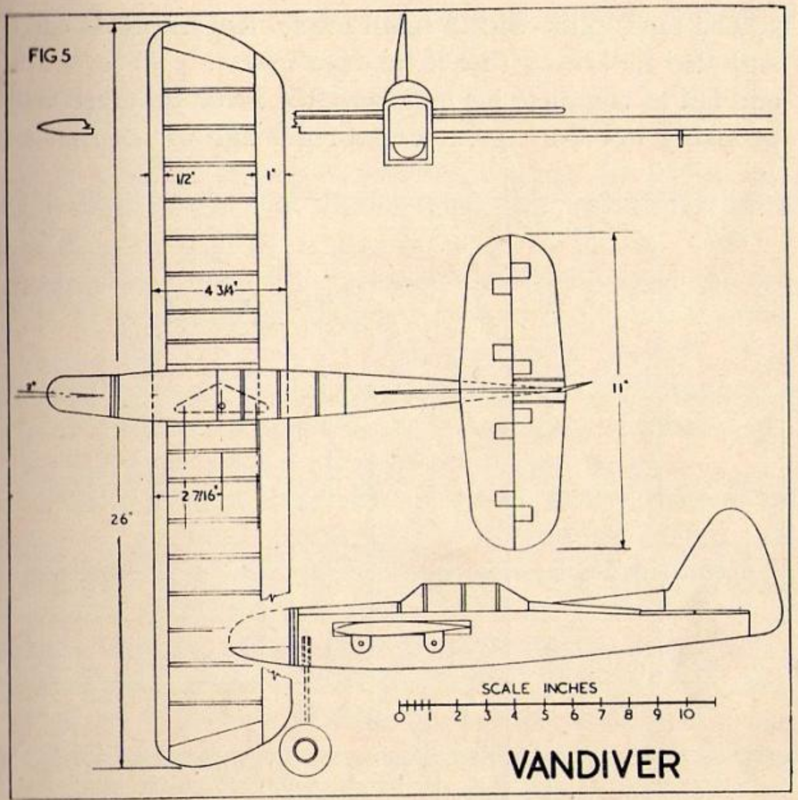
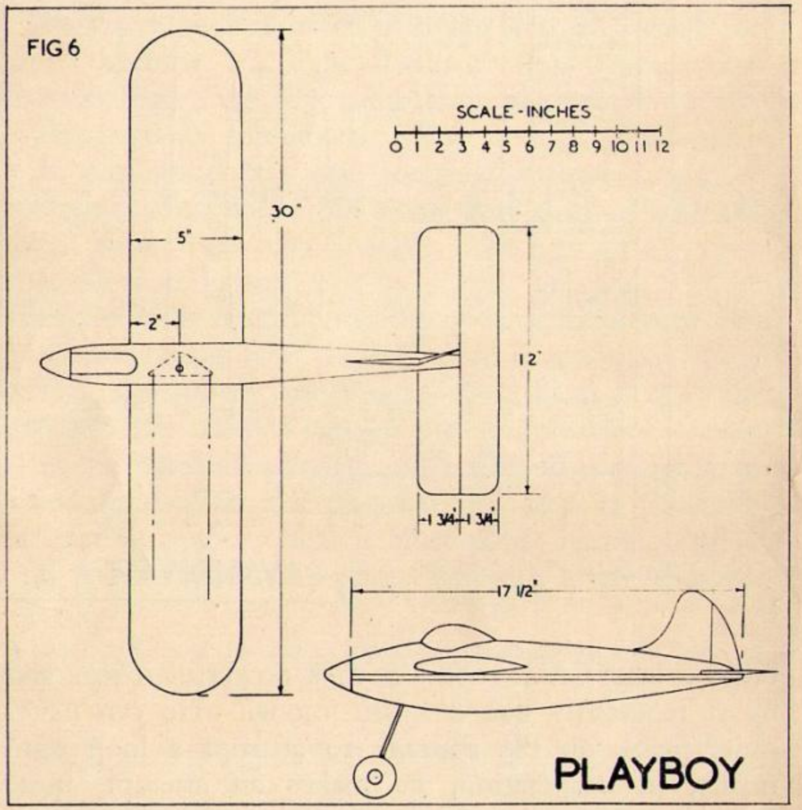


FIG 5

build a large stunt model with a powerful motor and fly it repeatedly like a sports model. He can never quite pluck up the courage to attempt a loop until finally, in desperation, he makes an attempt, quite frequently under unsatisfactory conditions.

A large model usually flies at at least 60 m.p.h., and probably seems even faster on account of the greater motor noise. There is also the certain knowledge that a crash will wreck the machine. And so, never having looped a control-line model before, the novice pilot faced with such a situation not unnaturally hesitates.

The same pilot with a small model feels more at ease, and also he knows that if he does make a poor attempt and fail to complete his first loop, the resulting crash will probably not do a great deal of damage to his model.



Once he has looped successfully he will gain confidence quickly and begin to appreciate that there is more to stunt flying than just completing a certain manoeuvre. When he can complete the elementary manoeuvres *smoothly* and with confidence he is well on the way to becoming a good stunt pilot.

The experienced flier can judge the flight possibilities of any new model by doing ordinary circuits and steep climbs and dives. Being proficient already at a whole range of manoeuvres by previous experience, he can, therefore, put any new machine through its paces with the minimum of risk. Basic flying time with simple stunt models can pay dividends over and over again.

Most of the British kit models produced up to the end of 1948 have been designed around the 1-2 c.c. diesel motor and are classed properly as sports models. Full stunt models—i.e., those capable of a full range of flight manoeuvres—are in the minority, but probably will form a greater proportion of the future market.

Three typical examples of good stunt designs are shown in Figs. 5, 6 and 7. The " Vandiver " (Fig. 5) is designed specifically to accommodate the Frog range of motors. Performance with a Frog " 100 " diesel is rather limited, the ideal power unit being the Frog " 160 " glow-plug motor. The Frog " 180 " diesel also is satisfactory. The type of structure is most readily suited to radial mounted motors, and other types which have proved extremely successful on this particular model are the Elfin (1.8 c.c. diesel) and the Arden .099 or .199 used as a glow-plug motor. In both latter cases a separate stunt tank is required which is located in the fuselage.

The " Vandiver " is a very smooth machine to fly. It is perfectly stable on lines of up to 45 ft. with a Frog " 160 " motor, although 40 ft. lines are the usual maximum. On 40 ft. lines the full stunt range is possible.

Pull on the lines during flight is very slight and may at times give the impression that the lines have slackened right off, although full control is there all the time. Side-mounting of the motor on a knock-off bulkhead reduces the risk of damage to the power unit to the extreme. The airframe, too, is very robust and capable of taking very hard knocks with little damage.

Proportions are about the optimum for the Frog "160" and similar motors and the layout can be used as a guide for free-lance designs around such power units. One possible improvement would be to thicken the wing section to nearer the optimum figure given in the chapter on "Design."

The "Playboy" is also a successful stunt model based on American layout. Designed originally around the E-D Comp. Special, performance is, if anything, better with an Arden .099 or .199 or Elfin diesel, on account of the reduced overall weight. A further increase in performance could be achieved by dropping off the undercarriage, as in the "Vandiver."

The basic layout approaches the ideal for stunt work very closely. Control response is positive and smooth and the same proportions hold good over a range of sizes up to 50 in. span. Again the wing section could be thickened with advantage.

As a stunt trainer the "Playboy" would be improved by side-mounting the motor and strengthening the tail anchorage somewhat. The tailplane is simply stuck on to the end of the crutch and is rather vulnerable in a crash.

Performance is comparable with that of the "Vandiver," although the pull on the lines is generally greater throughout and response to control movement rather more rapid. With adequate power it can be flown on line lengths up to 55 ft., but 40 to 45 ft. is the usual maximum.

The "Stuntmaster" is typical of the semi-silhouette type of model where some attention has been paid to appearance. A Mills diesel (1.3 c.c.) is the standard power unit, side-mounted to simplify construction and reduce

vulnerability. Proportions again are very well suited to the power unit specified.

Flying characteristics are good. The model is stable and maintains adequate line tension throughout. Res-

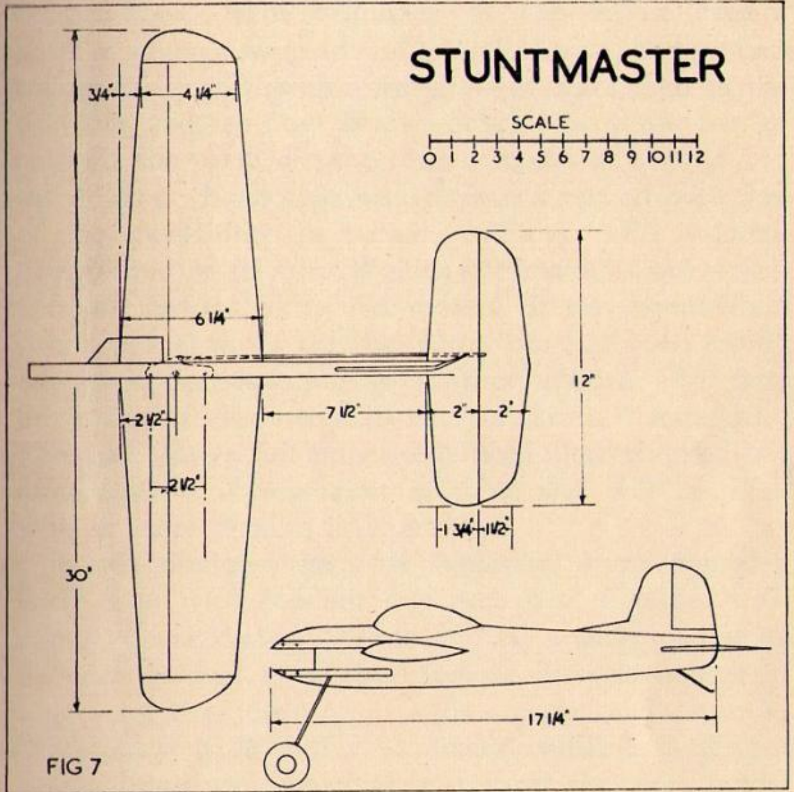


FIG 7

ponse to control movement is smooth, although not as marked as in the other two models. It would, of course, become more lively if a more powerful motor were used.

These three typical examples of commercial stunt models have been described at some length as giving the correct proportions for "stunt trainers" around typical British motor sizes. Whilst called "stunt trainers" they are, in capable hands, able to perform all the standard manoeuvres. They are good examples of a starting-off point for the beginner, or in laying out an "own-design" around similar motors.

CHAPTER II

DESIGN FOR STUNT

WHILST almost without exception the American stunt control-liners were originally in the larger class—with an average wing area of 400-500 sq. in., and powerful 10 c.c. spark-ignition motors—we have seen in the previous chapter how British development has tended towards the small diesel-powered model of around 150 sq. in. area. Each class was, in fact, a natural reflection of the availability of suitable motors. *The* original control-line model—Jim Walker's "Fireball"—was developed around a 5 to 7.5 c.c. motor. It was essentially a sports model in its original form, but has been highly developed subsequently as a stunt model. In fact, the modifications necessary to convert a "standard" "Fireball" into a full stunt model well illustrate the basic requirements of any stunt machine and will be dealt with in more detail a little later on.

It was obvious that, for successful stunt flying, a fairly light wing loading was necessary, together with a high power loading. That is to say a wing loading of between 10 and 15 oz. per 100 sq. in. was necessary, together with ample power for the size of model resulting. With a very wide variety of motors available, American design trend was immediately towards the large model (to reduce loading with orthodox structures), which naturally then called for the largest and most powerful non-racing motors available.

Probably one of the most outstanding of the early American stunt models was Dave Slagle's 1946 Nationals winner, which had a wing area of 415 sq. in. and was powered by a Super Cyclone motor—Fig. 8. Construction was quite robust and no particular effort was made to reduce structural weight to a minimum.

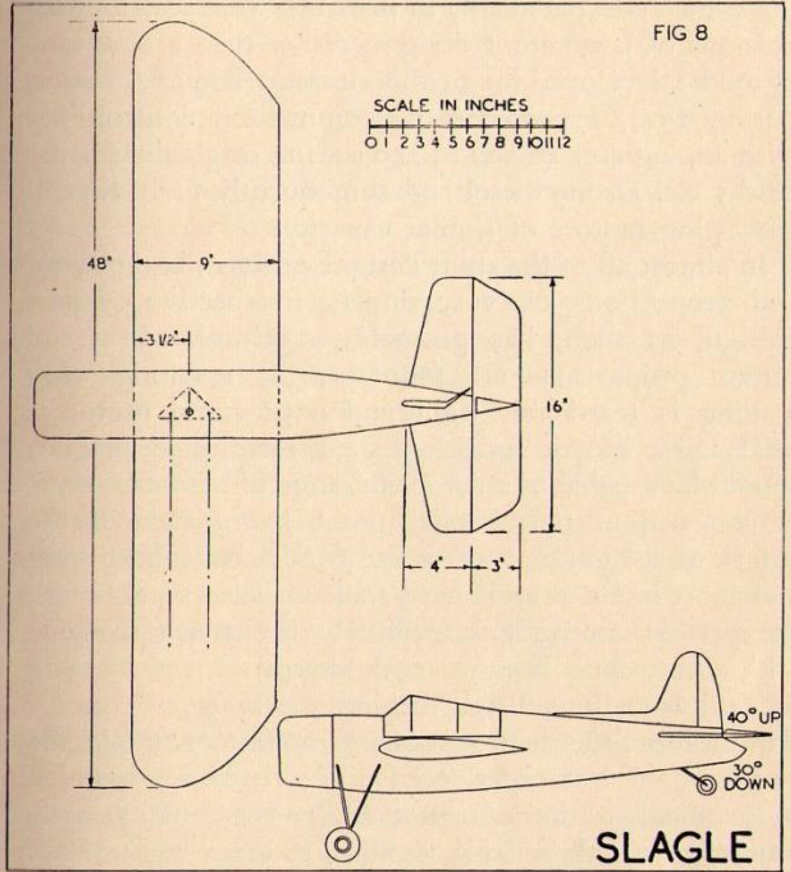
Without exception, all these models employed spark-ignition motors, with necessary ignition equipment and flight batteries carried in the model. The complete power unit, therefore, accounted for about 16 oz. weight, the weight of the airframe itself being anything up to twice this figure. For best performance only the most powerful Class C motors were satisfactory.

Some of the earlier efforts in this country were similar, but with lower power loading, resulting in an inferior performance. One of the author's original stunt models, for example, had 410 sq. in. wing area and weighed 3 lb. with an Ohlsson "60" motor. Although the actual wing loading worked out at 12.2 oz. per 100 sq. in. (17.5 oz. per sq. ft.), the Ohlsson " 60 " was not really powerful enough for the job and had to be " flat out " all the time, even for single loops.

When much lighter models of similar size were introduced—the " Boxcar " being a typical example—aerobatic performance was much improved, the looping radius being reduced to a very small figure. In these very light models everything is sacrificed to reduce wing loading. The lightest possible structure of adequate strength is built up around the most powerful motor available. Provided the resulting design is correctly proportioned looping radius may be reduced to as little as 10-15 ft.

Since, however, the only motors available in quantity in this country were diesels of between 1 and 3 c.c., attempts were made to produce models of similar proportions with even lighter wing loadings and greatly reduced area. Results obtained exceeded expectations

FIG 8



SLAGLE

and the same full stunt range was realised as with the larger models. The diesels, being self-contained power units, also greatly simplified the whole model.

The development of the small (British) diesel-powered stunt control-liner came at about the same time as American designers turned to small models designed around the best of their Class A-B motors, particularly for motors of this type using a glow-plug and thus eliminating the ignition circuit. These differed from the British designs mainly in that they were scaled-down versions of large stunt designs, rather than a new type of model developed for small motors. Also in America, during 1947, appeared the medium-sized control-liner with a wing area of 200 to 250 sq. in., originally for the new 5 c.c. Drone diesel and subsequently for powerful glow-plug motors of similar capacity.

In almost all of the stunt designs evolved, basic layout and proportions are very similar, irrespective of size. Design, as such, has proved non-critical. Provided certain proportions are followed, the resulting wing loading is reasonably light and a powerful motor is used and a model based on such established practice should be capable of a complete range of manoeuvres.

One major controversial point has remained—the length of the tail moment arm. Models with both long and short moment arms have achieved success, although the present tendency is definitely towards a machine with a very short moment arm, almost, in fact, locating the tailplane immediately behind the wing. A model with a short moment arm is far easier to stunt in the hands of the less experienced pilot. It responds much more quickly to the controls and has a very small looping radius, provided the layout is allied to low wing loading. The higher the wing loading—and the greater the power loading—the greater the diameter of the loop. From the point of view of appearance, a long moment arm is desirable and models of this type, properly designed and handled, can certainly have a comparable aerobatic performance. (Fig. 9).

The beginner undoubtedly will find that the short moment arm model is easier for him to fly and he will get the best results from this type of model until he is fully experienced. A model with a long moment arm—

particularly if it is fast—requires more skill to control successfully, but in general gives a more pleasing and smoother flight pattern.

Control-line model design does not lend itself readily to mathematical analysis. The flight forces are most complex, involving line drag, trim of the model and the gyroscopic action of the propeller, amongst others. The simple solution based on treating the model as a weight on the end of the lines acted on by centrifugal force is quite useless. So many other factors effect line pull other than the flying speed of the model.

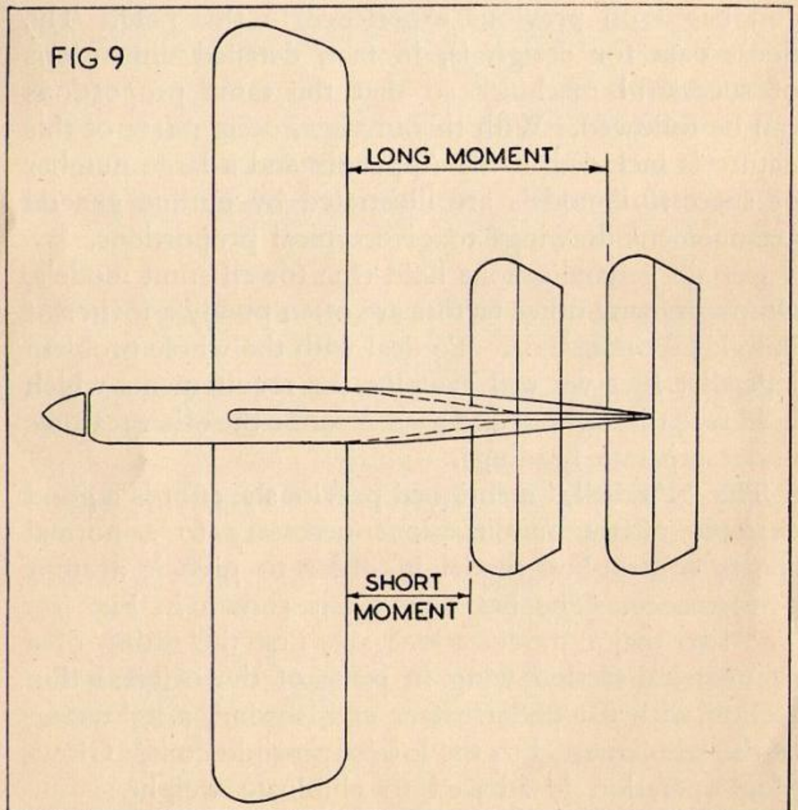
Hence, stunt model design is essentially practical and based on previous experience in this field. The finest data for design is, in fact, detailed dimensions of successful machines so that the same proportions can be followed. With this in view, design data of this nature is included in the Appendix and a large number of successful models are illustrated by outline general arrangement drawings to give typical proportions.

Certain generalisations hold true for all stunt models, although many other factors are often purely a matter of individual preference. To deal with the whole problem logically, first we will examine the requirements which hold true throughout and then describe the other features under separate headings.

The "Fireball," mentioned previously, affords a good example of the modifications necessary to a normal sports control-line model in order to give it a stunt performance. The basic design is shown in Fig. 10. The two major modifications are, first the fitting of a symmetrical-section wing in place of the original thin section with flat undersurface and, second, a lightening of the whole model to the lowest possible limit. Glow-plug operation is advised to eliminate weight.

To operate in all attitudes, a stunt tank is fitted to the motor. In the "Fireball" this takes the very simplest possible form, being just a rubber balloon cut down and fitted to a length of neoprene tubing. To give more effective control, elevator movement is increased by increasing the "throw" on the control plate and the balance of the model is altered slightly to assist in maintaining line tension at high altitudes. From these details, Fig. 11, we can draw the following generalisations which hold true for all stunt control-liners.

FIG 9



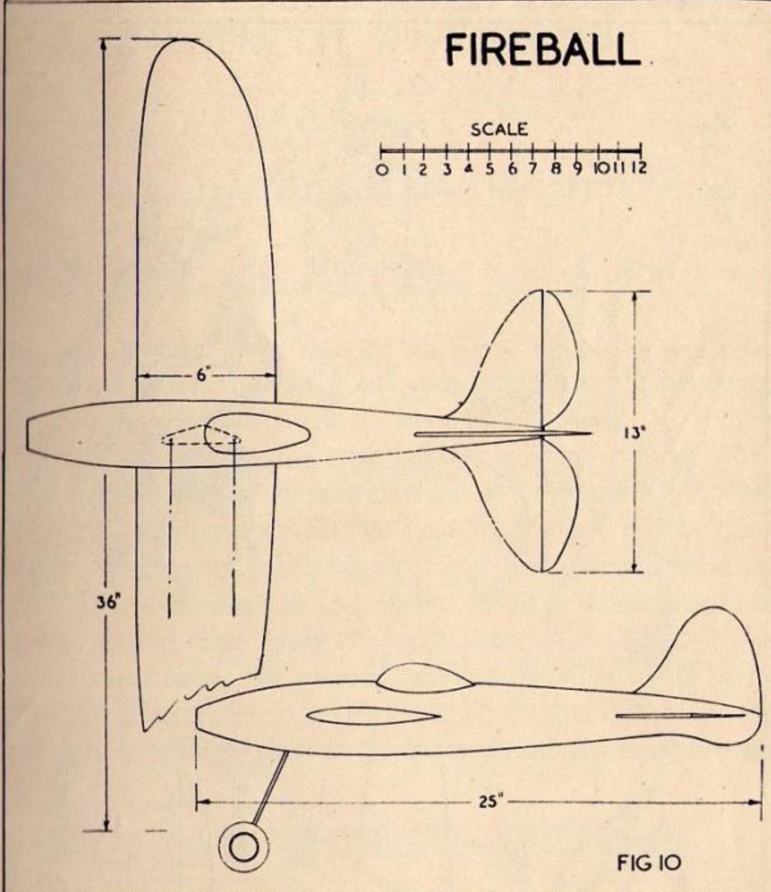


FIG 10

Symmetrical Wing Section

The conventional wing as used on sports control line models, with a section similar to a thin Clark Y with flat or near flat undersurface, has proved quite unsuited for stunt work. When a model with a wing of this type is inverted it is found almost impossible to maintain height, let alone attempt manoeuvres from the inverted position. This is because such a section

FIG 11

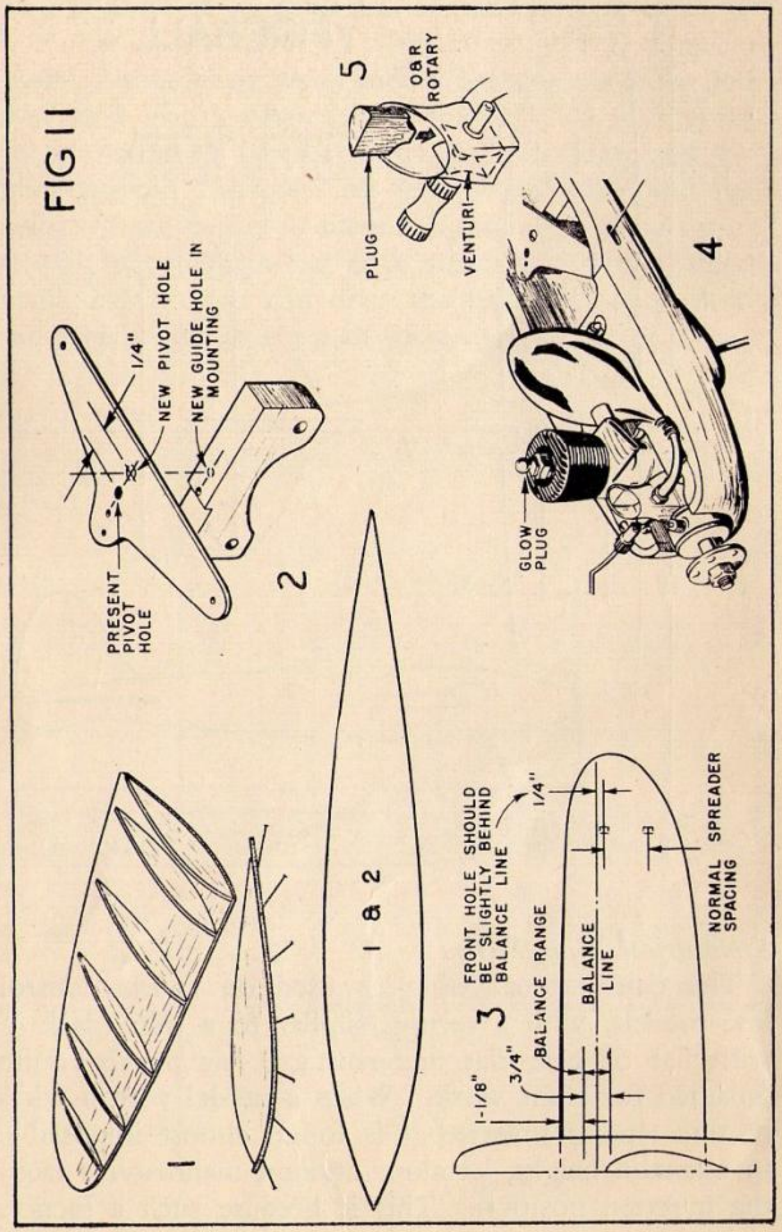
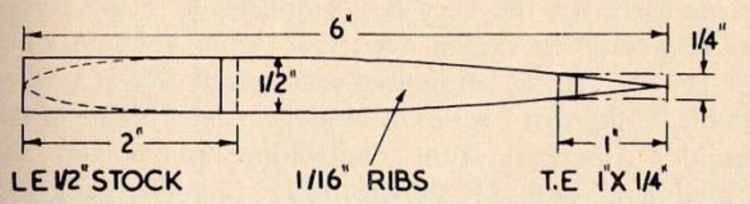


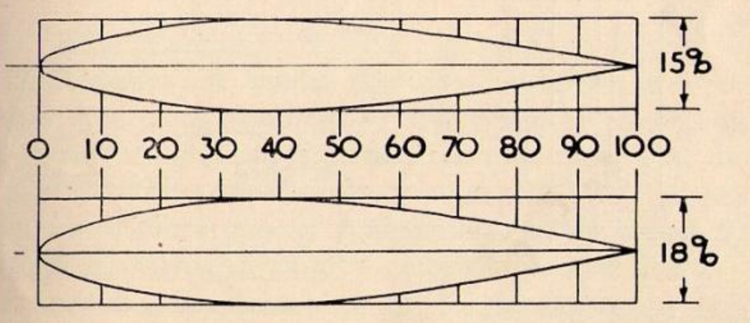
FIG 12 DRONETTE WING SECTION



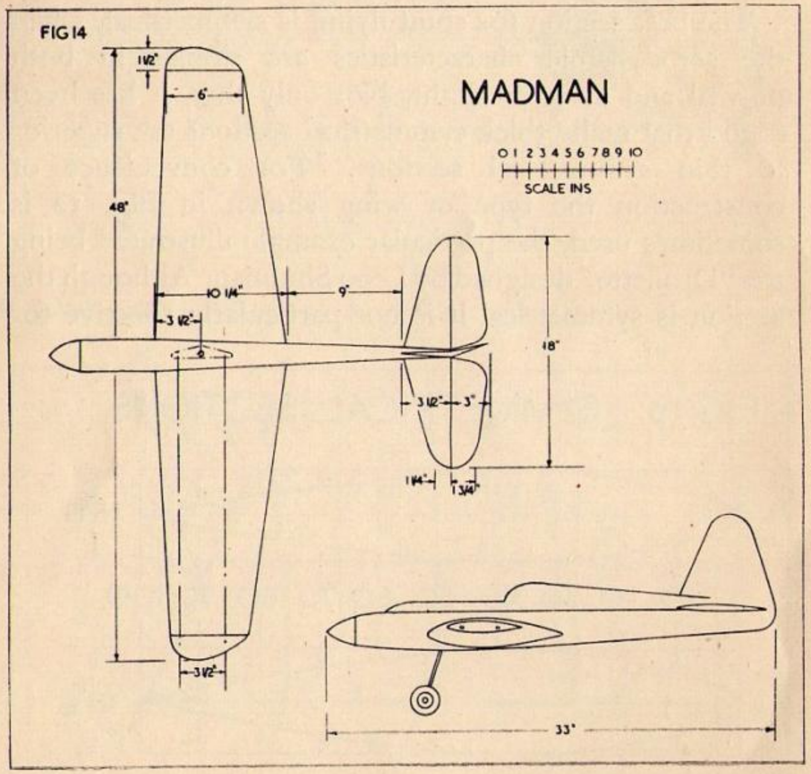
in its inverted position is very inefficient as a lifting surface and needs to fly at quite a high angle of attack to produce enough lift to maintain height.

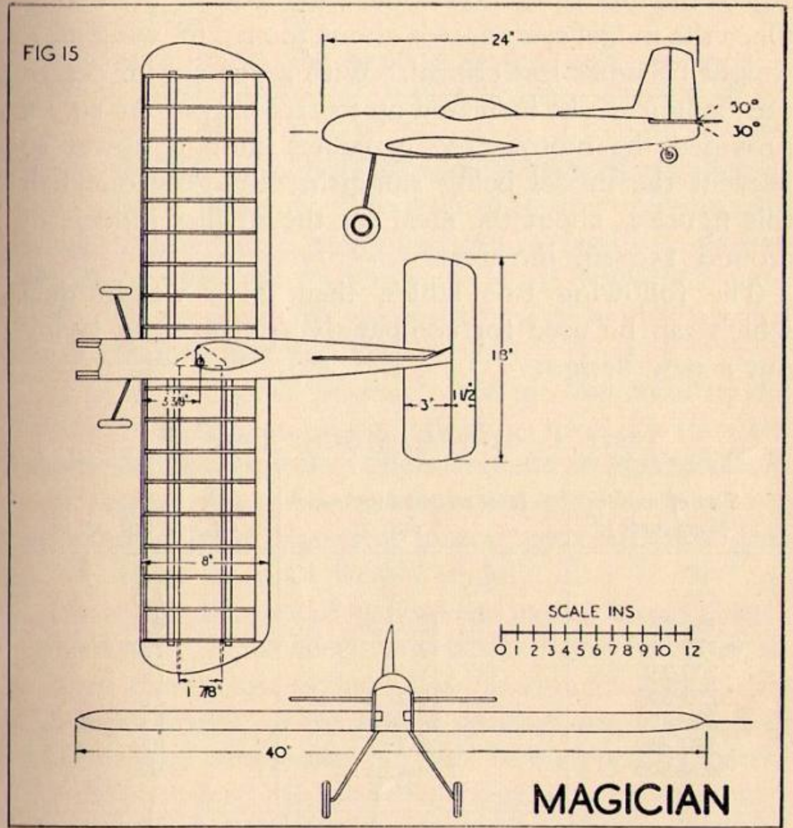
The best section for stunt flying is symmetrical, when the aerodynamic characteristics are similar in both normal and inverted flight. Not only that, it has been found that really thick symmetrical sections are superior to thin symmetrical sections. For convenience of construction the type of wing shown in Fig. 12 is sometimes used, the particular example illustrated being the "Dronette" designed by Leon Shulman. Although the section is symmetrical it is not particularly effective for

FIG 13 SYMMETRICAL SECTIONS



stunt flying and a thickness : chord ratio of as much as 15 per cent. is now generally recognised as the ideal. Particularly for the very large models, it is sometimes an advantage to exceed even this figure—NACA 0018 (18 per cent. thick) being used successfully by J. C. Yates on his " Madman " series of models. Yates is one of the leading American stunt control-line pilots and the " Madman " design is shown in Fig. 14. The wing section used here, together with a suitable 15 per cent. section, is shown in Fig. 13.





Low Wing Loading

The smaller the model the more important it is to reduce the wing loading to the practical minimum. As a very rough approximation the total weight of the model should be approximately twice that of the power unit, but a more general comparison can be drawn by analysing weights of various successful control-liners.

In general, the lighter the model the better the performance around a given motor; and the smaller the *size* of the model, the lower the wing loading the better. Once the model size exceeds about 300 sq. in. wing area, weight becomes less critical. With a 500 sq. in. design the loading can be increased up to 12.5 oz. per 100 sq. in. provided the motor used generates enough power to prevent the model being sluggish. Roughly one half this figure is about the ideal for the smaller models of around 150 sq. in. area.

The following two tables, then, give weight data which can be used for comparative purposes in laying out a new design.

TABLE I.—GENERAL WEIGHT DATA

Size of model (wing area)	*Total weight (optimum) oz.*	*Loading oz. per 100 sq. in.*
100	6	6.0
150	9	6.0
150-175	10-11.5	6.5
175-200	12-14	7.0
200-250	15-19	7.5
250-300	19-22.5	7.5
300-350	24-28	8.0
350-400	28-32	8.0
400-500	34-42.5	8.5

TABLE II.—WEIGHT DATA

Model	*Wing area sq. in.*	*Weight oz.*	*Wing Loading*	
			oz. per sq. ft.	*oz. per 100 sq. in.*
" Vandiver "	120	8	9.7	6.7
" Playboy 30 "	145	10	10.0	6.9
" Dronette "	206	25	17.2	12.0
" Hot Rock "	261	26	14.4	10.0
"Super Zilch"	500	48	13.8	9.6

See also Appendix Table D.

Adequate Power

However good the model design and the pilot's skill the final criterion as regards performance will be the power unit. Unless the motor develops enough thrust for the job, the full potentialities of the design will not be realised. Some motors are exceptionally powerful for their capacity and can be used in a variety of different designs. Others are more borderline cases and it is necessary to design a stunt model around them carefully for best results.

It is, in fact, good practice to design any stunt model around a particular motor, which is then the standard power unit for the job. Should results be unsatisfactory the design itself can be checked by stepping up the power by using a more powerful motor, provided this does not increase the total weight unduly.

Designing the model around the motor is particularly necessary in the smaller sizes, where many of the commercial diesels just do not develop enough power for full stunt work ; or the power performance is definitely marginal and best results can only be obtained by matching the motor to the model. Where a series of motors may exist—the Frog range being a typical example—all of similar size and weight, the most powerful of the series should be chosen. Dealing with this particular example, the Frog " 100," " 160 " and " 180 " series, the " 160 " is the most powerful motor of the three and would, therefore, be the logical choice.

The motor market is continually changing and new and more powerful units are being introduced. Hence, it is virtually impossible to give a comprehensive guide on this subject. However, Table III lists a number of standard motors which have been used with success on stunt control-liners, together with suitable model sizes.

This table can be used as a guide for determining model size for any other motor by selecting the model size given for a standard motor of comparative power. Thus, for example, suppose a new motor the X-100, was introduced, which showed itself about comparable in power with that of the Ohlsson "23." The Ohlsson model size given (200 sq. in.) would therefore be the right size of model, provided the resulting model could be kept within the maximum weight figure also given. (Note that this figure is *maximum* weight for good stunt performance—not optimum weight).

TABLE III.—TYPICAL MODEL COMBINATIONS

Motor	Model	
	Wing area (sq. in.)	Maximum weight (oz.)
Orwick	450-500	42-50
Super Cyclone ...	450-500	42-48
Attwood Champion	450-500	42-50
Ohlsson "60" ...	350-400	30-40
Madewell "49" ...	300-350	28-34
Sportsman Snr. ...	300-400	28-36
Drone	250-300	24-30
Sportsman Jnr. ...	250-300	24-30
Forster "29" ...	200	16
Ohlsson "23" ...	175-200	14
Arden .199	175-200	12-14
Elfin	150-175	10-12
E-D Comp. Special	150-175	10-14
Frog "160" ...	150	10
Mills, Frog "180," Frog "100" ...	150	10

Propeller

Much power can be wasted by fitting the wrong propeller and, in fact, the solution to an apparently underpowered stunt model is frequently a change in

propeller pitch or diameter. Provided the speed is high, r.p.m. at least 6,000, and preferably nearer 8,000 static (i.e., running on the ground), any motor should be capable of flying a stunt model of the right size as specified above. Selection of the best propeller is a matter of trial and error, for much will depend upon the actual layout of the design itself.

Stunt Tanks

Since a stunt model assumes a variety of attitudes during the course of a flight a special tank is needed in order to give a constant supply of fuel to the motor irrespective of the attitude of the machine and the forces acting on it. The normal type of tank as supplied with a motor would be quite useless, for example, in inverted flight. Some standard tanks, in fact, will not function in normal level flight since centrifugal force swills the fuel to one side of the tank away from the feed pipe.

Thus, with one notable exception, all stunt models are fitted with special stunt tanks. Tanks are a specialised subject of their own and can take many forms. A stunt model must have a good stunt tank and so this subject is dealt with at some length in Chapter IV.

The exception mentioned is in motors like the Frog series, with an integral tank which can give constant fuel supply if the motor is mounted on its side. Normally run inverted, centrifugal force now takes the place of gravity and conditions are similar in both normal and inverted flight.

Mounting a stunt tank may present something of a problem on some designs, particularly where the intake (carburettor unit) is mounted low as on motors with rotary disc valves. Ideally the tank should be positioned so that the feed pipe is roughly on the same level as the needle valve assembly. The fuel setting is then unaltered in inverted flight, but some experimentation is generally necessary to determine the best position. Some motors are non-critical as regards tank position, others extremely sensitive to slight variations in fuel head.

Motors with rotary crankshaft valves are most readily adaptable to separate tanks since the needle valve is generally mounted horizontally and it is relatively easy to adjust the tank level to that of the needle valve. But in all cases gravity feed in either normal or inverted flight positions should be avoided.

Further Developments

Other design features which have been considered to increase manoeuvrability include variable incidence wings—the incidence of the wings being increased or decreased with corresponding elevator movement to reduce the looping radius and give more rapid control response—and also variable thrust line—tilting the motor up or down in the direction of the required manoeuvre. At this stage neither of these schemes have reached the stage of practical application and do, in fact, seem unnecessary complications. Adequate control response is given by correct proportions.

CHAPTER III

DESIGN LAYOUT

BASIC requirements of a successful stunt control-liner are illustrated in Fig. 16, which gives all proportions related to the span of the model. An aspect ratio of 5 is pretty general for most models of this type, although this may be increased to 6, if desired, particularly on the larger models. The size of the model is determined by the motor to be used, as detailed in the previous chapter, and hence span can be calculated simply from the following :

$$\text{Span} = \sqrt{5 \text{ (or 6)} \times \text{wing area}}$$

All the other proportions for laying out the design then follow by simple calculation.

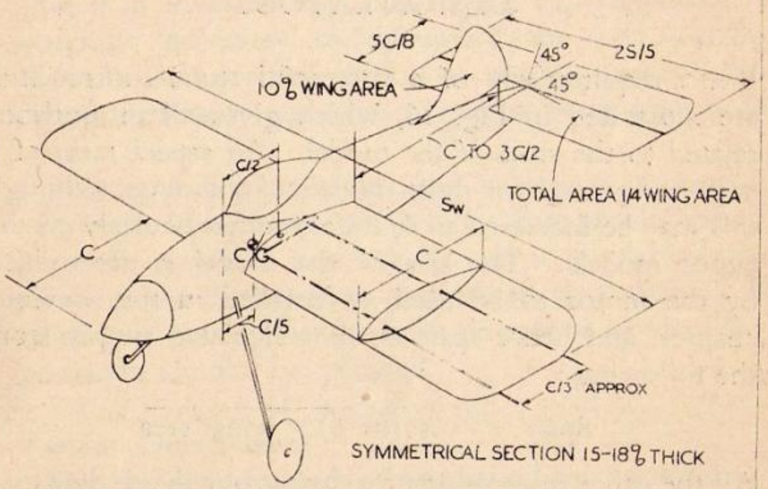
The various other aspects of outline design can then be discussed under separate headings.

Type of Model

Almost any type of model can be used for stunt work—high- or low-wing, biplane, and so on—provided each is correctly proportioned. Previous experience has shown that there is little to choose between them and often personal preference is the deciding factor.

Theoretically the mid-wing layout should be the ideal, where the thrust line, wing and tail can be located in one line so that the trim of the model is virtually the same whether upright or inverted. (Fig. 17.) Mid-wing models are, in fact, greatly favoured. For structural reasons, the wing is often placed slightly above or slightly below the true mid-position so that the wing can be

FIG 16



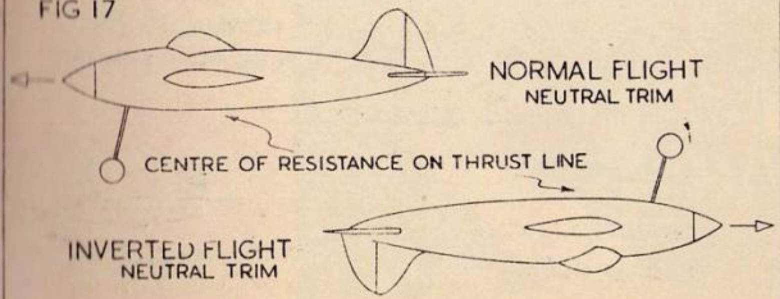
built in one piece for maximum strength. Where crutch construction is employed for the fuselage it is not possible to locate the wing on the crutch line (i.e., the true mid-position) without breaking the leading and trailing edge spars where the wing joins the crutch. Hence, location just above or below the crutch provides a stronger structure. However, this does not hold true where the crutch is positioned vertically as on many modern designs, the vertical crutch being used to accommodate a side-mounted motor. The great structural disadvantage of the vertical crutch is that the tailplane has little seating surface and local strengthening of the structure is needed here to provide a rigid fixing. Tailplanes which are fixed to the fuselage weakly are liable to frequent damage and may even develop flutter during flight.

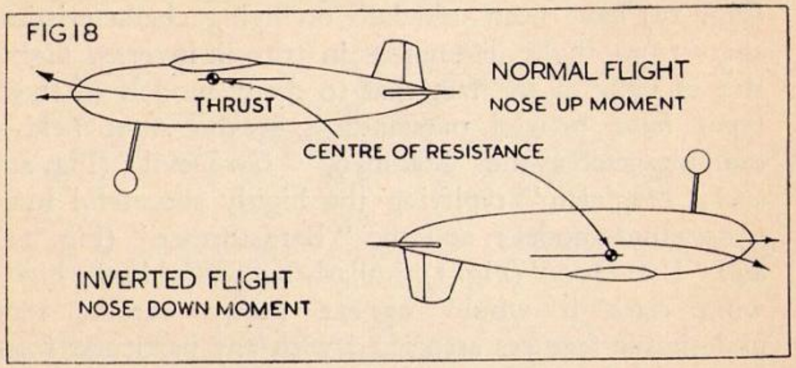
Both high-wing models (Fig. 18) and low-wing models

(Fig. 19) have been criticised on flying characteristics, apart from slight differences in trim in inverted flight. But in view of the fact that so many models of these types have proved outstanding in the stunt field—examples such as the "Madman," "Go-Devil" (Fig. 20) and "Magician" typifying the highly successful low-wing stunt model; and the "Barnstormer" (Fig. 21) and "Kan Doo" (Fig. 1) similarly successful in the high-wing class—it would appear pretty certain that undesirable features associated with any particular free-lance design of similar layout are due to some design fault rather than the layout itself.

From the point of view of appearance, mid- and low-wing models are superior. The low-wing model, in fact, can be given a particularly pleasing semi-scale appearance. One great structural advantage associated with both low- and high-wing models is the fact that the wings can be made detachable very easily, simply seating into a suitably shaped cut-out in the fuselage and strapped in place with rubber bands. Where a mid-wing model is made with detachable wings the wing must pass through the fuselage and is more prone to damage (or to damage the fuselage) if displaced in a bad landing or a crash.

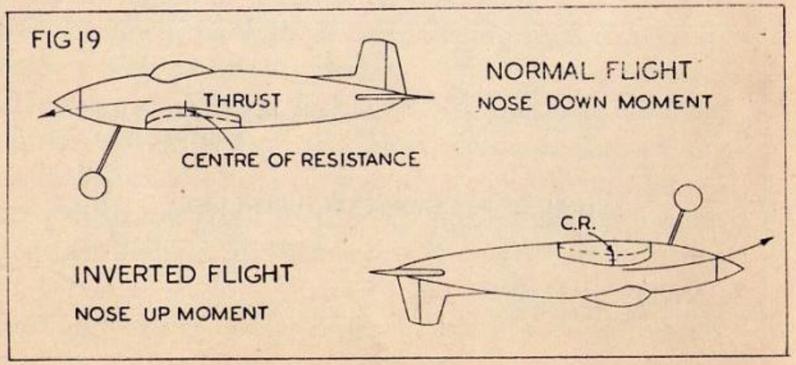
FIG 17





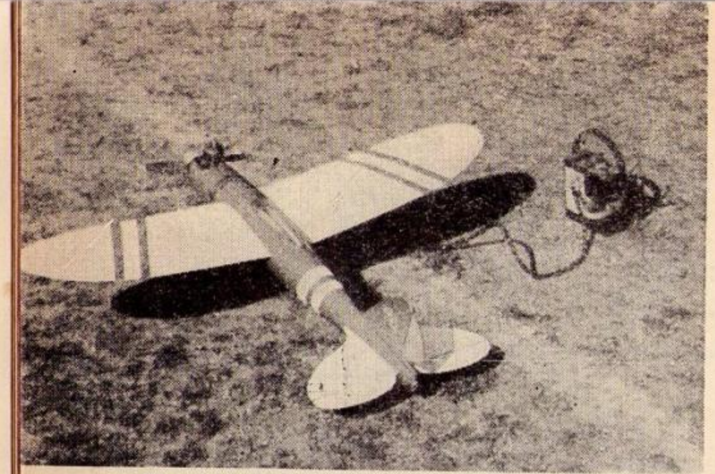
However, detachable wings are not generally favoured. Even with the largest stunt control-liners it is quite usual to secure the wings permanently to the fuselage, particularly in American practice. Detachable wings are more common on British models. (Fig. 22.)

A further advantage of the mid-wing layout is the fact that the lines can be led through the wings, with the control plate mounted in the wing centre section rather than in the fuselage. If the same practice is adopted with a high-wing model the control plate is inevitably mounted high in the model and, in flight, there is a ten-



Henry J. Nicholls (second from left) discussing with the author the merits of this modified version of De Bolt's " Bipe."

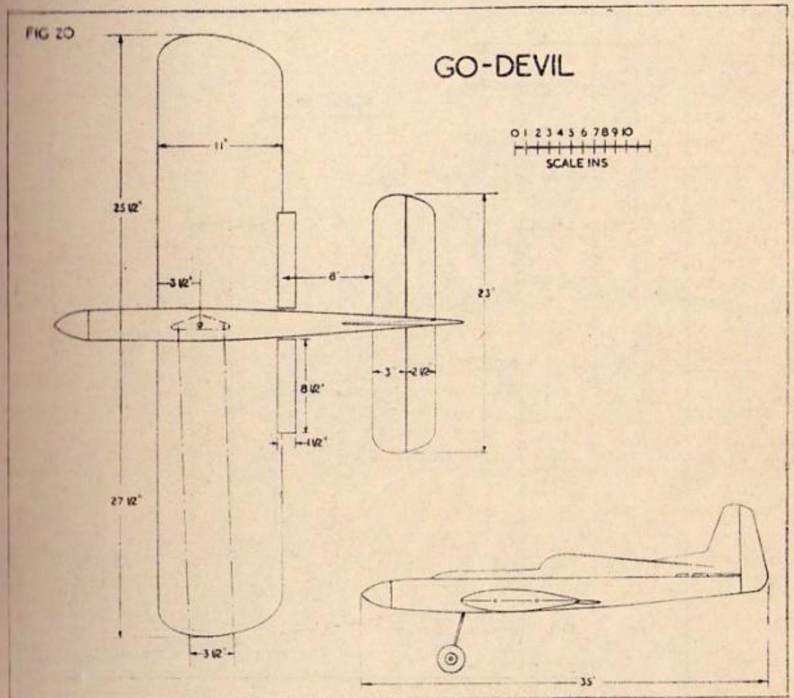
Semi-scale trend is typified by the model shown below. The tail unit is reminiscent of Shulman's " Dronette."



The first of the sports control-liners, the "Fireball" is readily adapted to stunt work by fitting a symmetrical section wing and lightening the airframe.

Mike Booth's "Barge" was one of the first successful moderate-power stunt models, in this case produced around the E.D. Comp. Special.

dency for the lower part of the model to swing outwards, i.e., the model assumes a bank inwards, which is not desirable. Similarly, with a low-wing model and low-mounted control plate the tendency is for the model to



bank outwards all the time, see Fig. 23. This effect is much safer, but gives an unnatural appearance in flight.

With high- and low-wing models it is more usual to locate the control plate centrally in the fuselage, with the lead lines outside the wings and passing through guides secured to and projecting from the wings themselves. Such schemes, of course, must be used with detachable wings where it is impracticable to mount the control plate in the wings.

Summarising this particular section it may be said that the mid-wing layout is the theoretical ideal and allows the lines to be led out through the wings readily and thus saves considerable drag. High-wing models

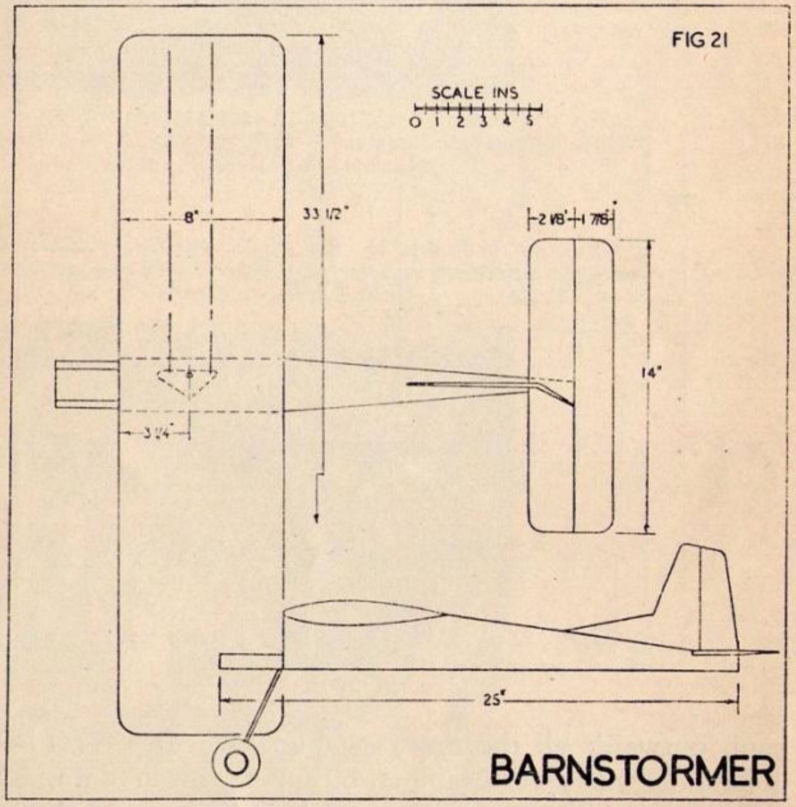


FIG 21

call for a control plate mounted in the fuselage with external lines under the wings and passing through a guide located near the wing tip. Low-wing models may use a similar scheme with the external lines above the wing; or lines passing through the wings as in the mid-wing layout with a low-positioned control plate.

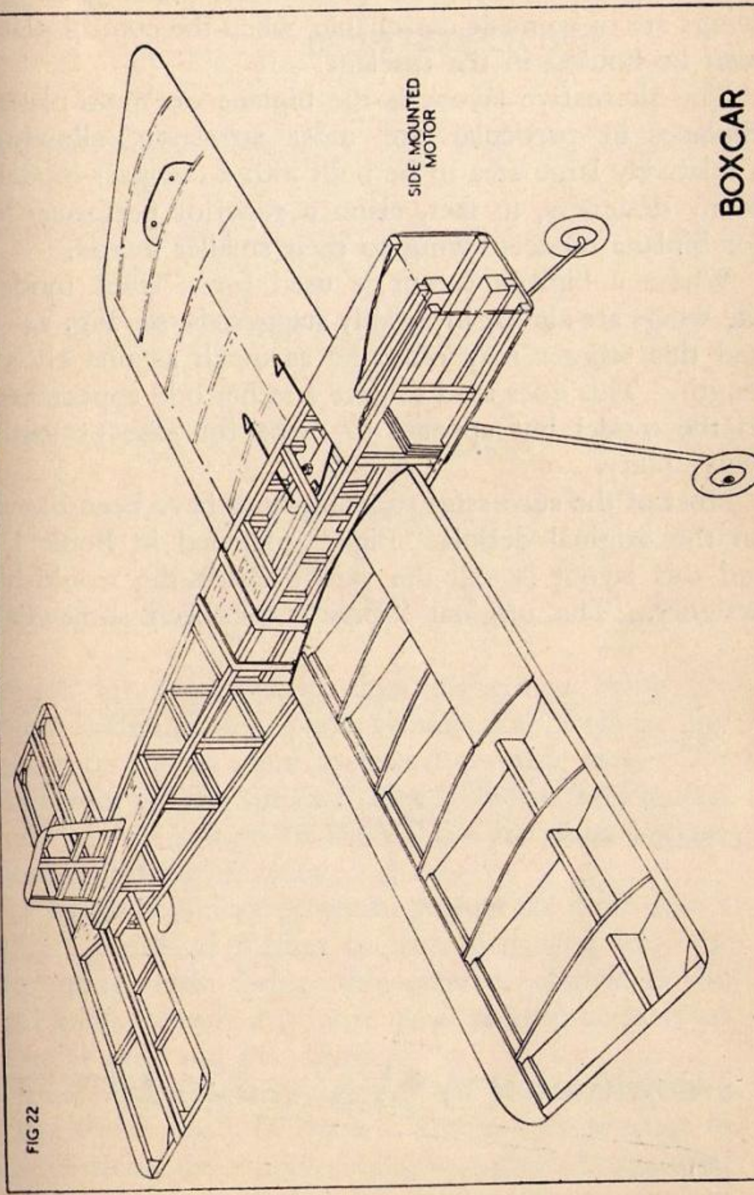


FIG 22

All of these schemes may need to be modified if the wings are to be made detachable, when the control plate *must* be housed in the fuselage.

The alternative layout is the biplane or multi-plane. Biplanes in particular are most attractive, allowing a relatively large area to be built into a compact model. Many designers, in fact, claim a superior performance for biplane models owing to their smaller inertia.

Where a biplane layout is used for a stunt model the wings are almost invariably staggered—see Fig. 24—and this stagger may often be as much as one chord length. This does tend to give a rather odd appearance to the model but appears to make for ease of manoeuvrability.

Most of the successful stunt biplanes have been based on the original deBolt " Bipe " (detailed in Book I), and this layout is still the yardstick for the would-be designer. The original " Bipe " has been somewhat

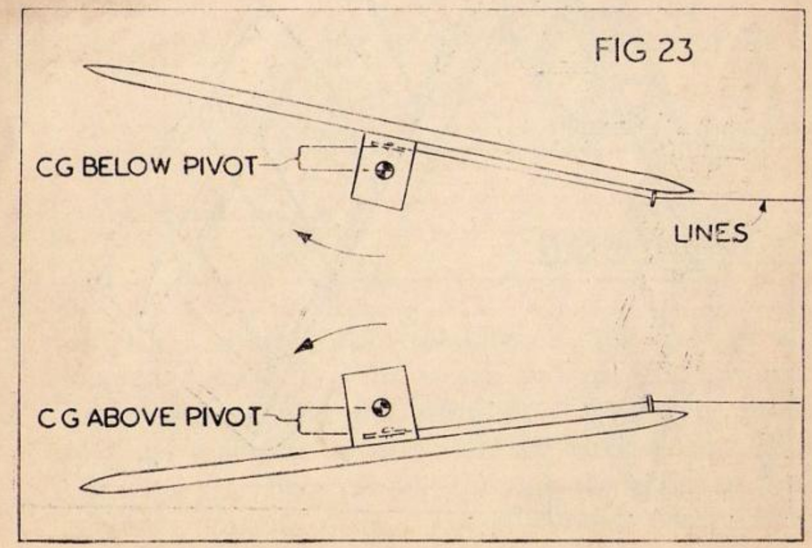


FIG 23

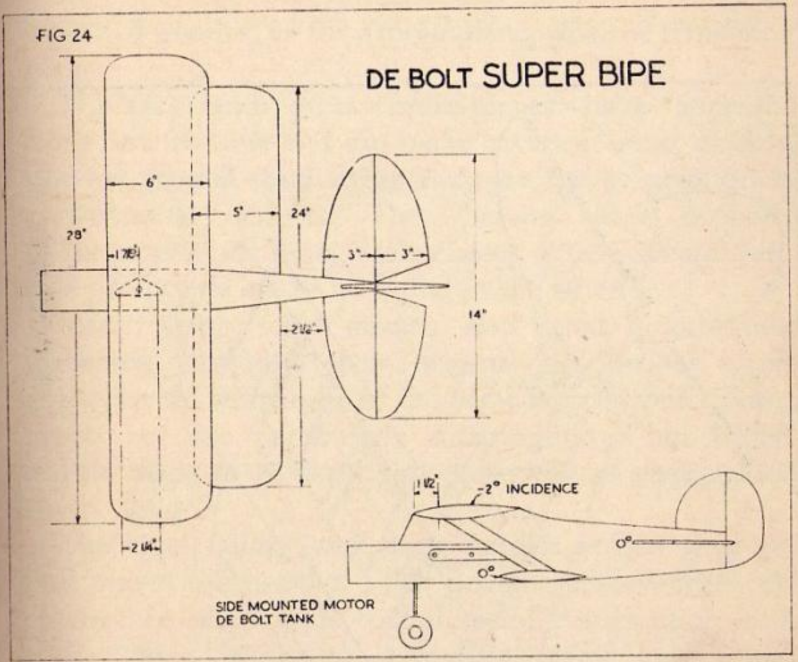
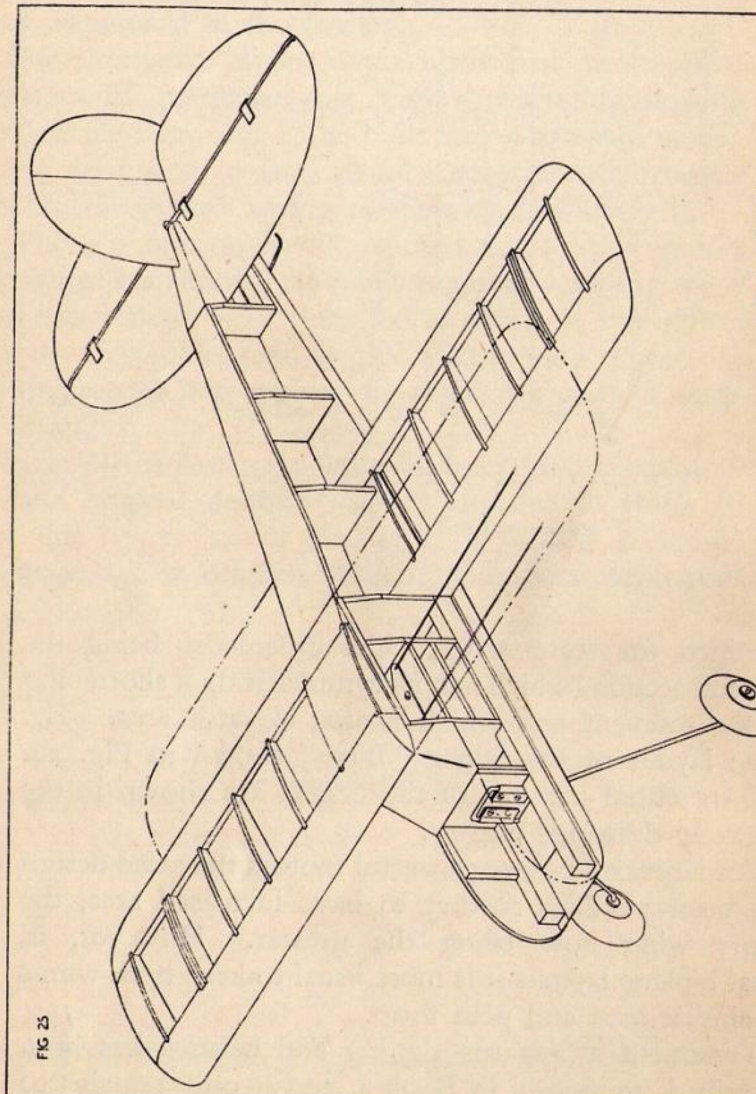


FIG 24

modified for stunt work, chief differences being the aerofoil section (which is now symmetrical), a shortening of the moment arm and increased elevator area. The basic layout of the Super " Bipe " shown in Fig. 24, and structural features of the deBolt are shown in the cut-away drawing, Fig. 25.

For larger and more powerful motors the same design has been modified further to have increased area, the upper wing now being the greater. However, in most biplane layouts it is more usual to keep both wings of similar area and plan form.

Treatment as regards rigging and balance has been described previously in Book I, and it only remains to repeat here that the simplest solution is given by ignoring the rear (or lower wing) and locating control plate and



DE BOLT BIPE

FIG 25

centre of gravity, as for a monoplane, with the remaining wing.

Triplanes and other multi-planes have appeared from time to time and can make excellent stunt models. But for normal stunt flying they are not as practical as conventional designs. They belong more properly to the novelty or flying scale classes, where several suitable prototypes are to be found in the latter.

Many flying scale models also make good stunt machines, provided their original proportions agree fairly closely with those of the ideal stunt layout. Some prototypes are particularly disappointing, but others can be made to perform almost as well as a specialised stunt design.

The chief failing with scale models is that they are built much too heavily. The desire to achieve true scale appearance often leads to semi-solid construction with sheet covered wings and a resulting wing loading well above the optimum for good stunt work. As a result these models may be manoeuvrable to the extent of performing single loops of relatively large radius, and flying inverted, but cannot hope to have a full stunt range. Yet there are many attractive prototypes which offer considerable possibilities, particularly some of the light planes with fabric covered wings of generous area and relatively large tail surfaces.

Development of the full stunt flying scale control-liner is still in its infancy. Many of the most successful machines of this type have been of World War I aircraft where the biplane and triplane layout has made light wing loadings relatively easy to obtain, and almost all the best models have used diesel or glow-plug motors in order to reduce the weight of the power unit to a minimum.

There is little doubt that a flying scale model with a stunt range equal to a free-lance stunt design is a far more attractive proposition as a spectacle, and probably the greatest advances towards popularising the movement can be made in this direction.

There is another design trend which must be considered, this really utilising the easy-flying properties of the short moment arm layout. The result is an unorthodox machine which is virtually a flying wing. The wing and tail are made one unit, with the elevators hinged to the trailing edge of this combination. Excellent manoeuvrability is possible with unorthodox stunt models of this type, although the style of flying is not usually as smooth as that of a conventional machine. In other words, the flying wing model will tend to flop round loops and similar manoeuvres rather than fly them smoothly, since control response is so rapid. For smooth flying with such types some considerable practice is necessary.

Since this is a type which will appeal to many modellers a typical layout and relevant design data applicable to all flying wing control-liners is given in the Appendix along with orthodox design data.

The Moment Arm (2*C*/3 to 3C/2)

The moment arm shown on the basic layout drawing, Fig. 16, is what could be considered " long " and Table A in the Appendix shows how this can vary on different successful designs. Leon Shulman's " Dronette " has about the longest moment arm of any stunt model, this figure being 2 × the wing chord. The Zilch series on the other hand has a moment arm slightly less than one chord length.

The figure given of 3/2 × cord length is about the

usual maximum, with 2/3 chord length as a minimum. Any figure between these two should be satisfactory, the shorter moment arm making for a more sensitive model and could well be used with a smaller elevator travel (see section on Elevators). A model with a long moment arm generally has a more pleasing appearance than one with a very short fuselage. As a general rule—the faster the model the longer the moment arm desirable.

The Wings

Nine out of every ten stunt control-liners have parallel chord wings with blunt or rounded off tips. There is no readily apparent reason why this should be so, other than simplicity of construction, for elliptic (" Fireball "), or tapered wings (" Madman ") are equally successful; but equally strong is the argument that simple rectangular wings have proved so successful that there is little reason to depart from this layout.

The low-aspect ratio rectangular wing is definitely compact, which is a desirable feature on a control-liner, and the fact that all the ribs in the wing are the same size is a great help in construction. A rectangular one-piece wing is generally stronger than a tapered wing of comparable size and is also less liable to warp during construction.

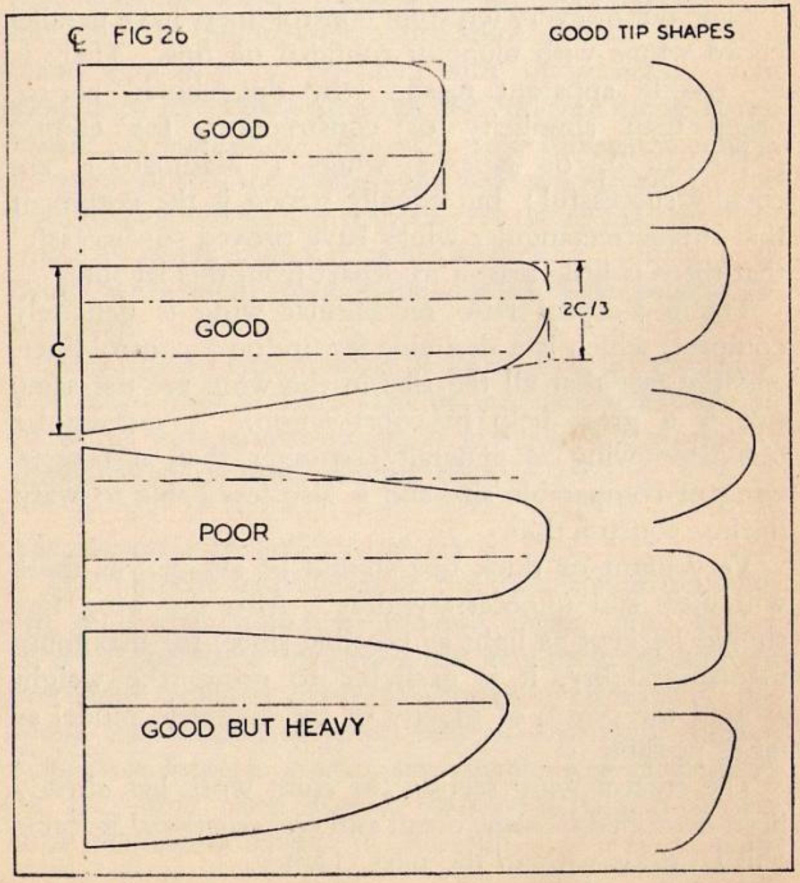
Very blunt or thick tips should be avoided as these will only add unnecessary drag. Also the wing tips should be kept as light as possible since, for maximum manoeuvrability, it is desirable to group the weight around the centre of gravity of the complete model as far as possible.

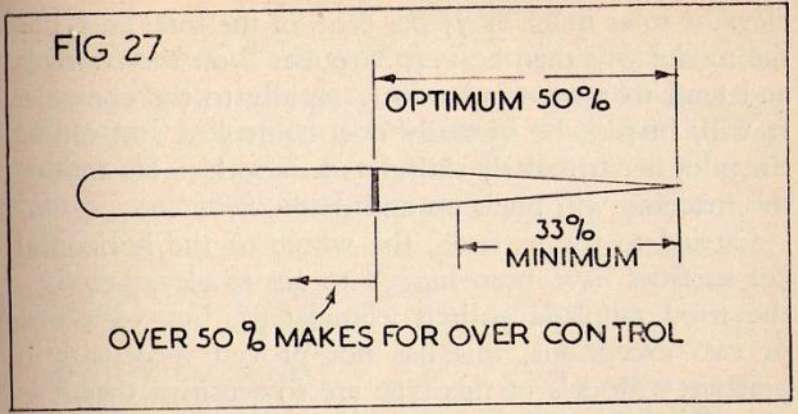
The correct wing section for stunt work has already been described in some detail and constructional features will be dealt with in the next chapter.

No dihedral is necessary on the wings, unless a degree or so be used to improve appearance on semi-scale layouts.

Tailplane and Elevation

A generalisation applying to all control-liners is that a total tail area of 25 per cent. of the wing area is adequate for stability, other proportions being correct. There is little or no advantage to be gained in increasing the





tail area above this figure and, in fact, a smaller area is quite frequently used. (Table A, Appendix.)

This figure holds true irrespective of the tail moment arm. Theoretically, the longer the tail moment arm the smaller the tail area required, but any variation of control with moment arm is so non-critical in practice that it is unnecessary to complicate the issue by introducing a formula to bring in this additional factor. What variation in area is most desirable is that the smaller models of under 200 sq. in. wing area should have the full 25 per cent. tail area; larger models generally will have similar stability and control with smaller proportions down to 20 per cent. of the wing area (this even with a short moment arm of one chord length).

The simple rule that the elevator area should comprise 50 per cent. of the total tail area works extremely well for all stunt control-line models, and again no other formulae are necessary in order to obtain satisfactory results.

On very small, low-powered models (and particularly those intended for indoor flying on short lines) it may be an advantage to increase the proportions of the elevator to as much as 75 per cent. of the total area, but the model will then be very " touchy " on the controls and tend to respond extremely rapidly to the controls. It will, in fact, be virtually over-controlled and unless the pilot is particularly skilful and smooth in his actions the machine will buck up and down.

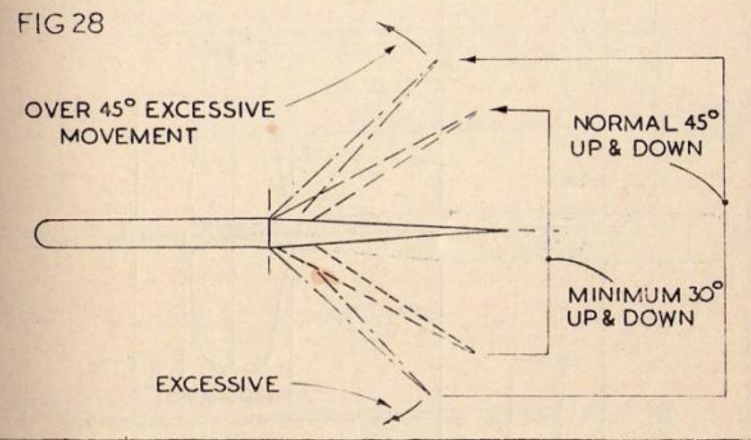
Carried to the extreme, the whole of the horizontal tail surfaces have been hinged to act as elevators (i.e., the fixed tailplane entirely eliminated), but with one or two exceptions, this has not proved successful in practice. Models of this type are so sensitive that it is virtually impossible to control them. The slightest control movement results in a steep climb or dive and holding the model in level flight may be a feat in itself.

One of the outstanding exceptions is the " Glo-Bug," designed by Carl Goldberg, where the elevator area is virtually 100 per cent. of the total tail area. This layout is also adopted sometimes for small control-liners intended for stunt work indoors on very short lines (20 ft. or less).

Too much control movement is just as bad as too little, particularly if the machine is only moderately powered. The rapid change of attitude induced by large control movement may stall the model—particularly after a manoeuvre such as a loop—and the model must be recovered from this stalled attitude before another manoeuvre can be attempted. As a typical example of this, a model with only moderate power and excessive control movement may loop quite readily, but if full "up" elevator is held on it, it may not perform consecutive loops at all. More likely it will complete one very quick loop, stall at the bottom of it and remain staggering round in a stalled attitude until the controls are neutralised once more.

Most models of this type can be stunted quite successfully by using only that amount of control movement necessary to complete the manoeuvre without stalling at the end, but it is not good practice to have more control movement than is necessary.

FIG 28



On the other hand, control action must be powerful enough to change the attitude of the model rapidly as required, and practice has indicated that a minimum of 30 deg. movement is necessary for close loops, and similar manoeuvres. The useful maximum is similarly 45 deg. (up and down), greater movement than this making for over-control. (Fig. 28.)

With the standard size elevators specified (50 per cent. total tail area) and a long moment arm the full 45 deg. up and down elevator range should be employed. With short moment arms it may be found advantageous to reduce the movement to 30 deg. to make for smoother response. This is a matter which is determined readily during the test flying stage. All new designs should have a possible elevator range of 45 deg. up and down, and

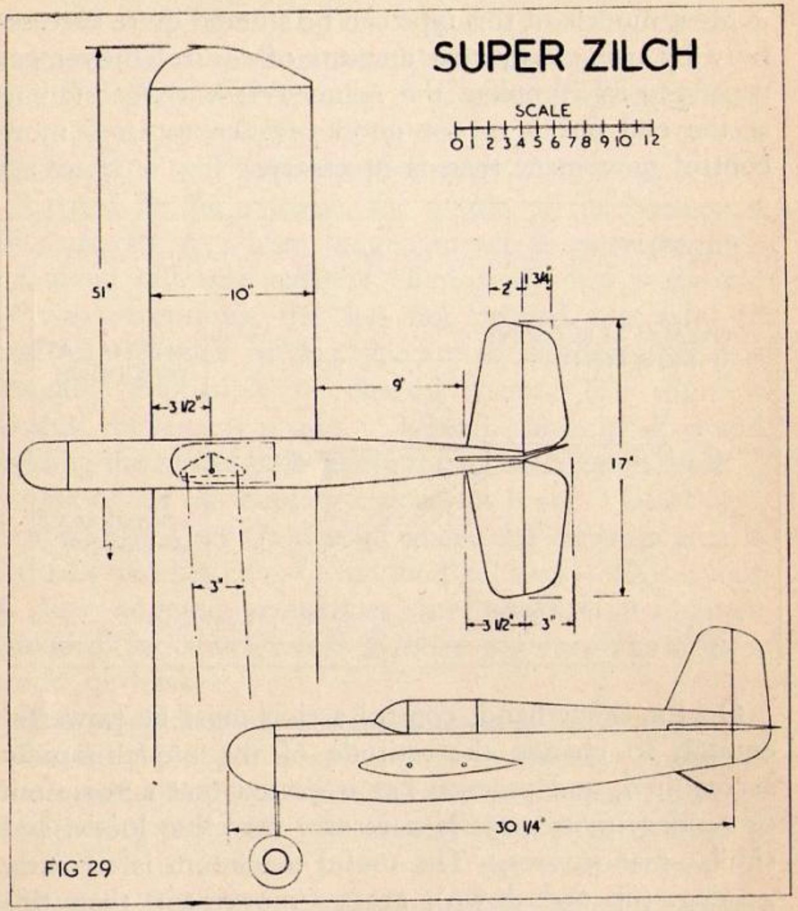


FIG 29

this can be stopped down slightly if it is found to make response too abrupt.

Particularly on models with a short moment arm, an elevator of reduced area may give better control for stunt work, especially on large models. About 33 per cent. of the total tail area is a practical minimum, this again being typical of the "Zilch" series where, incidentally, the total tail area is only 15 per cent. of the

wing area. The "Super Zilch" in particular is an outstanding stunt model. (Fig. 29.)

Tailplane shape is relatively unimportant. The purely rectangular plan form with rounded tips is used widely,

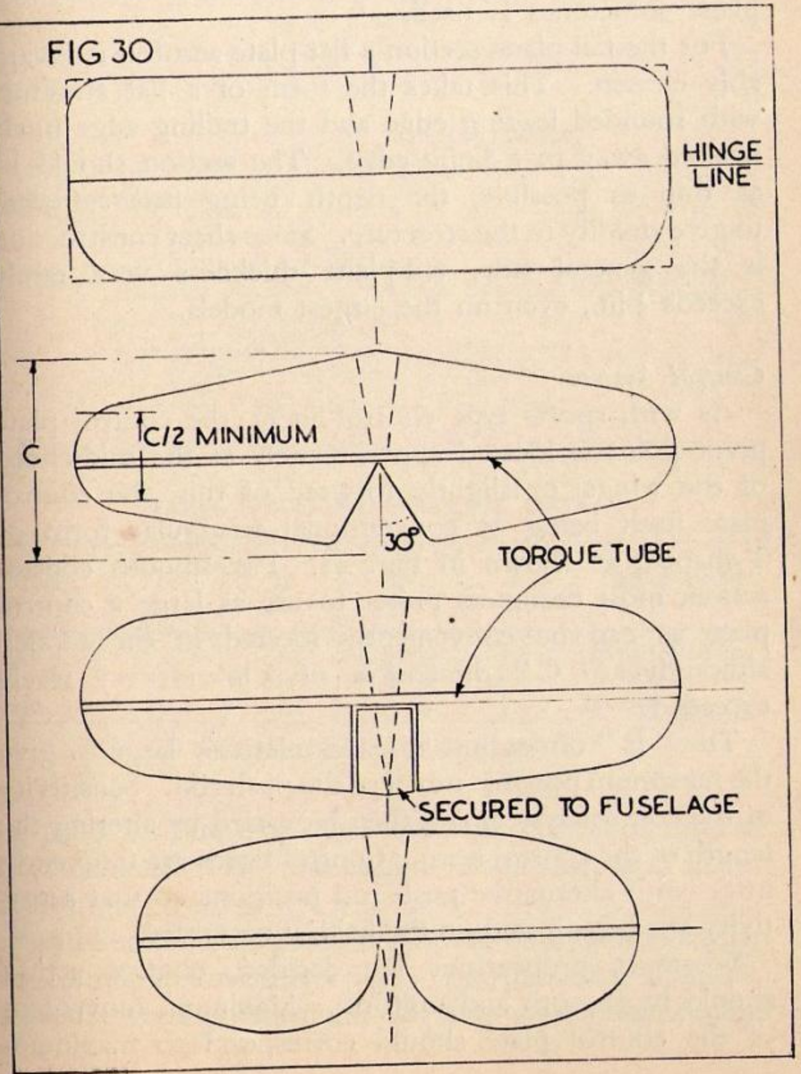


FIG 30

especially where a one-piece elevator is employed. With split elevators mounted on a torque tube a tapered planform is more usual, which generally takes the form of straight taper on both leading and trailing edges with rounded tips—see Fig. 30. The elliptic type tail-plane sometimes is used.

For the tail-plane section a flat plate aerofoil is invariably chosen. This takes the form of a flat structure with rounded leading edge and the trailing edge finely tapered away to a knife edge. The section should be as thin as possible, the depth being just sufficient to give rigidity to the structure. Since sheet construction is the general rule, tail-plane thickness very rarely exceeds $\frac{1}{4}$ in., even on the largest models.

Control System

As with sports type control-liners, the control plate pivot point is located approximately at the mid-chord of the wings, or slightly forward of this, the control plate itself being of conventional triangular form or T-shaped, as shown in Fig. 31. For smooth control action, most designers prefer to use as large a control plate as can be conveniently located in the model, although a "C" dimension of 3 in. is very rarely exceeded.

The "E" dimension is made relatively large to give the maximum possible travel to the push rod. Sensitivity of the control system can then be varied by altering the length of the control horn. Control horns are frequently made with alternative push rod positions so that sensitivity can be adjusted on the field, if necessary.

Whatever proportions are decided, control action should be smooth and uniform. Maximum movement of the control plate should correspond to maximum

elevator travel and there should be no slack in the system. That is, with the control plate fixed it should not be possible to move the elevators at all.

Control plate data is summarised in Table IV below, these being typical of present-day practice. Where commercial control plates having alternative positions for

FIG 31

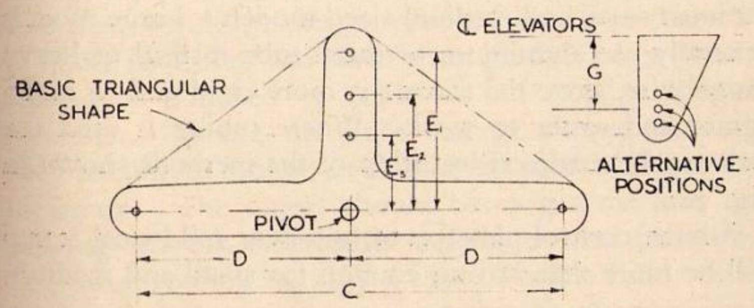


TABLE IV.—CONTROL PLATE DATA

Type	*C in.*	*D in.*	*E in.*	*G in.*	*size of model*
Small	2	1	$\frac{1}{4}$ & $\frac{7}{16}$	$\frac{1}{4}$-$\frac{3}{8}$	Up to 150 sq. in.
Medium	$2\frac{3}{4}$	$1\frac{3}{8}$	$\frac{5}{8}$ & $\frac{15}{16}$	$\frac{5}{16}$-$\frac{1}{2}$	150-300 sq. in.
Large	3	$1\frac{1}{2}$	$\frac{5}{8}$ & $\frac{7}{8}$	$\frac{3}{8}$-$\frac{5}{8}$	250-500 sq. in.

See also Table in C Appendix

the push rod are employed the hole corresponding to the maximum "E" dimension should be used in all cases.

Lead lines and the push rod should be anchored freely, yet securely to the control plate. Pay particular attention to the former and make sure that they cannot bind on the control plate itself or any part of the airframe over the whole range of movement. The push rod is a very important part of the system and it is very important to ensure that it will not whip under compression. If the push rod is too flexible it will tend to bow when the controls are given " up " instead of transmitting the full load to the elevators. In extreme cases, a flexible push rod can lead to elevator flutter.

Spring steel wire of adequate size is generally suitable for most small and medium sized models. Large models generally use aluminium or dural tube instead of heavy gauge wire, since the former is more rigid and so much lighter and easier to work. Where tubing is used the ends can be made off by either of the methods shown in Fig. 32.

For the control-plate pivot, a 6-B.A. mild-steel screw will be more than strong enough for small and medium

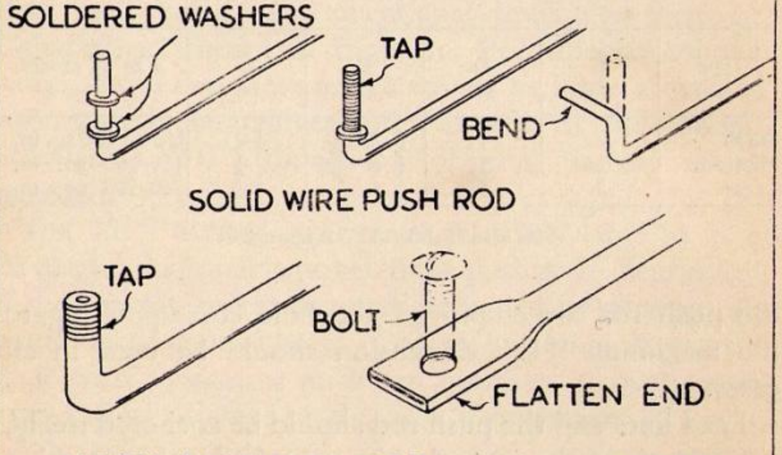


FIG 32

size models. Larger models—those weighing more than about 24 oz., should use a 4-B.A. screw. The very large and heavy models generally have a pivot screw of about $\frac{3}{16}$ in. diameter equivalent. All these sizes give a more than ample safety factor.

Control horns may be any of the types detailed in Book I, according to the elevator system used. On stunt models the control-horn is invariably mounted under the elevators so that the rear line is the " up " line (i.e., a pull on the rear line raises the elevators).

If the lead lines are taken through the wings the ribs should be punched or hollowed out to give adequate clearance. Where the lines emerge through the tips they should be located in aluminium tube with generous clearance. The object should be to get the lead lines bearing only on these tubes and the control plate itself, i.e., never fouling any of the ribs. To this end it should be noted that at the centre section the clearance holes in the ribs will need to be elongated since the lead lines have a fore and aft travel as well as in and out.

With the control system completely installed and linked up, the whole should be quite free so that if the elevators are raised to the up position and released they should fall to past neutral under their own weight. This is not always possible, particularly on small models, but is a very desirable feature if the model is to be flown on long lines.

Fuselage

Design of the fuselage is mainly a structural problem. Outline shape is relatively unimportant. To reduce drag and weight to a minimum the size of the fuselage should be kept as small as possible. Any shape which fits in well with the layout of the model is satisfactory from the flying point of view. More attention can be given, of course, to the appearance of the finished model.

Where the mid-wing layout is chosen the fuselage should be roughly symmetrical in elevation shape about its centre line. A simple cabin or cockpit can be introduced on the upper decking to improve the appearance. Bubble-type cockpit covers are much favoured for this. Alternatively an open cockpit or hinged cabin can be made to serve a useful purpose, such as housing the flight battery where a spark-ignition motor is used.

Proportions of the fuselage follow from the basic layout diagram, or may be determined from an established design of similar size and with the same class of motor. The nose length of one (wing) chord length shown holds true for most medium and large models irrespective of the type of power unit employed. On the smaller models with diesels of between 1 and 2 c.c. capacity a slightly shorter nose is indicated.

In general, most of the smaller models with standard diesels require a very short nose to balance. The weight of the motor is generally greater than that of the rest of the airframe and in laying out the basic design it is usual to mount the motor as close to the wing as possible. The " Playboy," illustrated earlier, with the original E-D motor is a typical example where the motor is so located that the tank is actually inset in the wing and the intake tube overlaps the wing. The " Vandiver," on the other hand, follows the general rule of a nose length equal to the wing chord, with the motor actually mounted on a bulkhead a short distance in front of the wing leading edge. However, it must be borne in mind here that the E-D diesel has a considerable overall length in comparison with other similar types.

Rigging Angles

Rigging angles for a stunt model follow conventional control-line practice. That is, both wings and tail are rigged at zero incidence with respect to the fuselage datum and the thrust line is also zero. Offset thrust, i.e. sidethrust against the flight circle, is sometimes used to help to maintain line tension, this being particularly effective on the smaller models. In fact, on almost all stunt control-liners of around 150 sq. in. area or less it pays to start with about 2-3 deg. thrust offset.

The factors affecting line stability and assisting in maintaining line tension have been dealt with in detail in Book I, to which reference should be made for further information on this subject.

Balance

Correct balance is important on all control-line models and more especially on a stunt model where the flight attitude is frequently such that the natural tendency is for the model to slacken off the lines.

Actually centre of gravity position does not appear at all critical, the one important factor being that it should not be too far aft. As with sports models, the centre of gravity is usually never farther aft than halfway between the front line and the pivot point or 25 per cent. of the chord (whichever is the smaller distance) but a more forward position is usually chosen. When the pivot is located well forward certain modern designs now have a c. of g. position approaching the pivot point to give greater maneouvrability.

With the c. of g. well forward the natural tendency is for the nose of the model to swing outwards, thus assisting in maintaining line tension, Fig. 33, which is obviously what is required. However, getting the c. of g.

too far forward will make the model trim appreciably nose-heavy so that a certain amount of up elevator will be required to maintain level flight. During manoeuvres a nose-heavy trim is not particularly helpful as the model has virtually to be " corrected " after recovering from

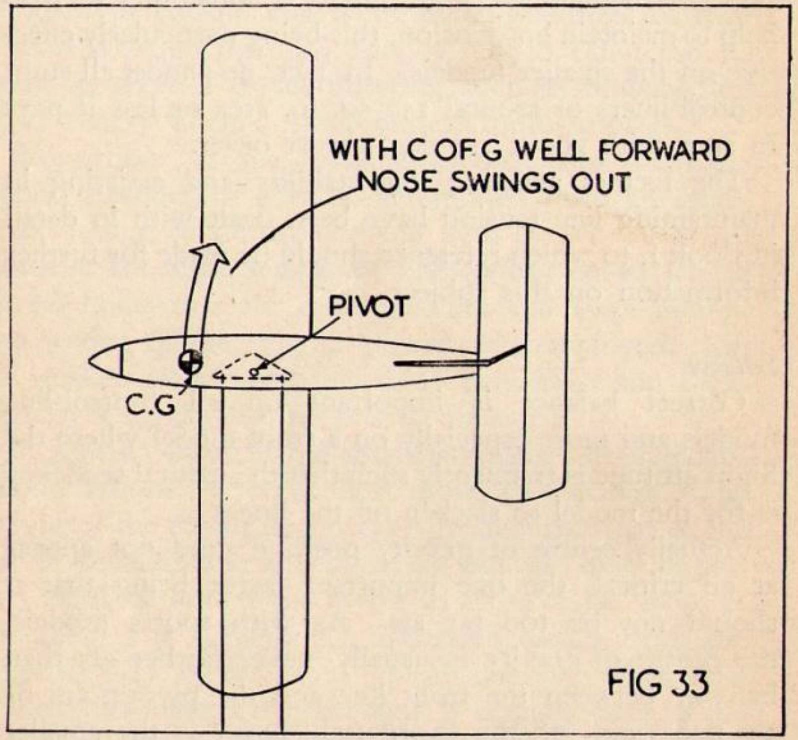


FIG 33

any particular stunt. Particularly if the nose down effect is marked, the model always seems to be trying to dive away from the pilot.

However, this is not likely to be noticeable to any great extent as long as the c. of g. is still behind the leading edge of the wing. A favourite position is on the front line, although some fliers prefer it farther forward—approximately halfway between the leading edge and the

front line. This is particularly true of small or moderately-powered models, where a forward c. of g. position is most helpful in retaining line tension.

On many of the large models, however, better manoeuvrability is obtained by moving the c. of g. as far back as possible without running into trouble, often approaching the aft limit. Line tension is then maintained by other trimming methods and the use of a large and powerful motor.

Since practice does differ so widely the best method of analysing the problem is to tabulate data of various typical designs as a guide to future practice. Appendix Table B lists data of this nature.

Undercarriage;

From the point of view of sheer performance undercarriages are an unnecessary evil, especially in the case of smaller models. Their usually high weight and drag can detract seriously from the performance of a medium-powered small-size model, whilst in the larger sizes their relative effect is not so great.

Small models can be hand launched and it is not unusual to see stunt models of this class built without undercarriages. Landings are made by skidding the model along the ground, the lower part of the fuselage being reinforced or fitted with a hardwood skid to take the consequent wear. Since small models land at relatively low speeds, little or no damage is likely to result, even to propellers. Care must be taken, however, if such a scheme is adopted, to make sure that all parts of the motor are well clear of the ground during " landing." For example, side-mounting an Arden or Elfin motor, the needle valve projects below the model and must be suitably modified or protected.

However, the practice of flying stunt models in this fashion is not to be recommended. In contest work points are given for take-off and the appearance of a model with an undercarriage is very much better than one without.

An effective compromise has been worked out in the case of the "Vandiver." Here the undercarriage plugs into metal tubes in the fuselage. The unit is a loose fit in these tubes and is free to drop out once the model is airborne. Thus normal take-offs are possible, the undercarriage jettisoned for maximum flight performance and a belly landing made at the end of the flight.

This method can be used to advantage on small models which are frequently handicapped for take-off on account of the small size of the wheels. Wheels of adequate diameter for take-off from grass surfaces are generally out of all proportion to the rest of the model, as well as making the undercarriage unit unduly bulky and heavy.

On the larger models with ample power reserve the question of undercarriage weight and drag does not appear so important and it is more usual to employ a conventional fixed undercarriage. The effect of jettisoning the undercarriage of any model after take off is most noticeable, the decrease in drag resulting in a very considerable increase in speed in all cases. Hence, fixed undercarriages, when used, should be as simple and light as is practicable, with streamlined section wheels. Balloon-type wheels add much unnecessary drag and are very seldom used on control-line models.

Wheel diameter should be as large as possible, depending to some extent upon the nature of the take-off surface from which the model will normally operate. For take-off from smooth asphalt surfaces 2 in. diameter wheels

are quite suitable for the smaller models, with 2½ in. wheels for the larger jobs. But wheel size can be increased with advantage for operation from grass—3½ in. diameter being about the right size for the largest class of models. A similar increase in wheel diameter is not always possible on smaller models without making the whole undercarriage look ridiculous and have a prohibitive drag, but it is generally possible to find a relatively smooth patch for take-off.

The one general rule applying to all undercarriages is that they should be located as far forward as possible to give maximum ground stability. If the undercarriage is mounted too near the c. of g. the model will tend always to nose over in landings and take-offs. With the wheels in the best position, i.e., just behind the propeller, tail-up landings are possible on good surfaces.

To improve ground stability further during take-off both wheels can be raked outwards slightly, so that the model tends to run outwards and maintain line tension as soon as released. Nothing is more annoying than a model which tends to run into the circle as soon as the take-off commences.

These difficulties should not apply as much to stunt models as to sports types. Stunt models generally have power to spare and the take off run should be very short. On most successful stunt models, in fact, it is possible usually to take off with little or no forward run by applying full up elevator from the moment of release.

CHAPTER IV

AIRFRAME CONSTRUCTION

SINCE the optimum wing loading of a stunt control-liner is higher than that of a comparable free flight model, construction is, naturally, rather more robust. A stunt model, too, is subjected to far greater stresses than its free-flight counterpart. At the same time excessively heavy structures must be avoided.

The most highly stressed component of a stunt model is the wings. These have to withstand quite considerable loads, particularly in sharp pull outs at the bottom of steep dives and in tight loops, etc. Furthermore the load is frequently reversed as in inverted flight.

Strength requirements for large and small models are slightly different. The small models have a low overall weight and require a slightly lower wing loading for best performance. In spite of a lighter structure they generally have a higher overall strength factor on account of their smaller size.

With small models it is more usual to find free-flight type construction employed for both wings and fuselage, both components being tissue covered. With larger models the general rule is sheet covered fuselage, although this is not invariably the case. The " Super Zilch " which is one of the largest stunt models, employs a built up, paper-covered fuselage.

Construction is usually straightforward throughout and the more rugged airframe makes the control-liner easier to build than a competition-type free flight power job. Apart from the risk of crashes when attempting advanced manoeuvres, the useful life of a control-liner

expressed in terms of actual flying time should be quite high. This means that, once competent at stunt flying, a model can be given a really good finish.

Some control-line designers take the other view. To them the model itself is of secondary importance. They regard it as purely functional and the standard of workmanship is cut down to the minimum required to give a reasonably strong model, irrespective of appearance. This method may produce good results as far as flying is concerned, but is not to be recommended.

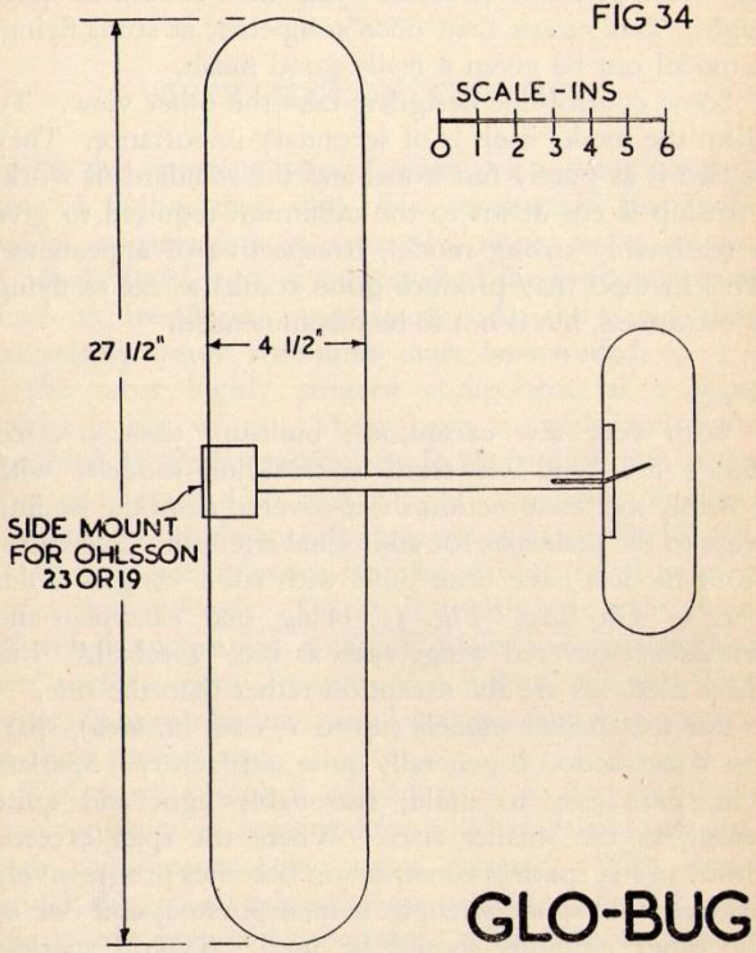
Wings

With very few exceptions, built-up, tissue-covered wings are used on stunt control-line models, with possibly the front section sheet-covered from the leading edge to the mainspar for additional strength. Successful stunt models have been built with solid wings—Goldberg's " Glo-Bug," Fig. 34, being one example—and with sheet covered wings such as the " Fireball." But these methods are the exception rather than the rule.

For the smaller models (up to 175 sq. in. area), sparless construction is generally quite satisfactory. Sparless wings are easy to build, reasonably light and quite strong in the smaller sizes. Where the span exceeds about 30 in., sparless construction becomes progressively heavier if adequate strength is incorporated, and one of the other methods should be used. Typical sparless construction is shown in Fig. 35.

Monospar construction, Fig. 36, is generally employed on models between 175 and 300 sq. in. area. This may take the form of a single, deep spar centrally located through the ribs, or smaller section top and bottom spars. In the latter case it is often usual to sheet cover top and bottom surfaces from the leading edge to the spar.

FIG 34



GLO-BUG

The monospar wing is inherently lighter than the sparless type and where weight is of extreme importance smaller models may use one of these forms, since it allows a considerable reduction in leading and trailing edge sizes and consequently less bulk (and weight) of wood. Sheeting in the front portion is not necessary

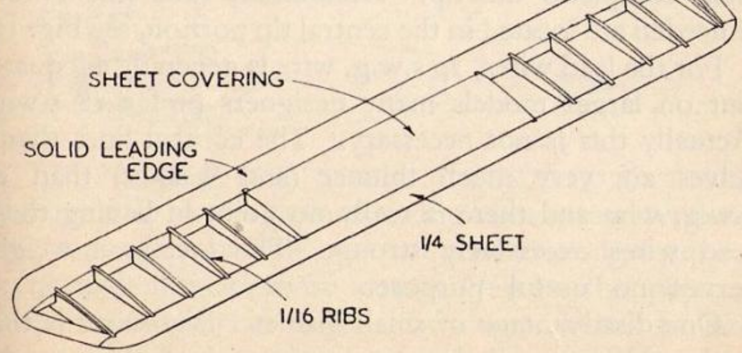
on wings of less than 250 sq. in. area, except possibly in the region of the centre section where the wing may be subjected to handling.

For the very large wings, two-spar construction is the general rule, since now the chord of the wing is quite large. Instead of locating each spar centrally, the front spar is often let in to the upper surface, see Fig. 37, when the upper front portion can be sheet covered for the full span length. Sheet covering can be used for the centre section bottom, simply let into the ribs. Alternatively, the front spar can be split up into a top and bottom spar to fit in with full span sheeting-top and bottom.

Large wings have proved quite successful with the conventional two-spar arrangement and no sheeting—the " Playboy 50 " being a typical example—but such wings have a definite tendency to flex. Sheeting makes a very rigid structure at very little increase in weight.

Particularly on larger models, the centre section portion of the wing requires strengthening. If the wing is at all heavy, stresses on the centre section may be considerable,

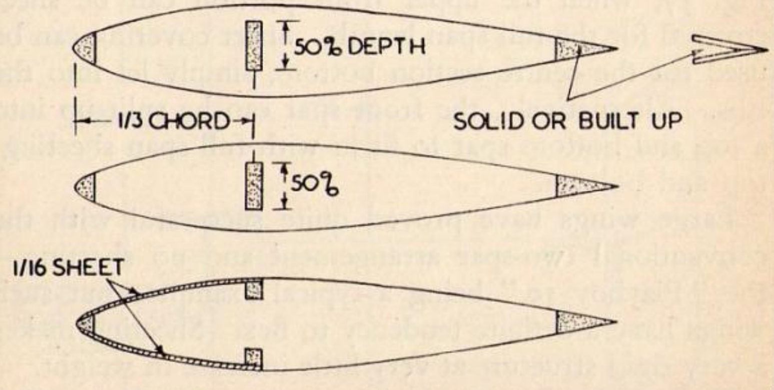
FIG 35 DRONETTE WING



particularly in a heavy landing. Thus the spars in this region can be faced with ply, or an additional hardwood spar laminated to the main spar to take care of this. The lighter the wing the better in this respect.

Tip construction is fairly straightforward. With the

FIG 36 MONOSPAR WINGS



normal parallel chord wing, tips can be carved to shape from light block balsa or built up from sheet. In the latter case one sheet section is located centrally, cut to the actual tip shape. Thin sheet covering top and bottom then completes the tip. Aluminium tube line guides if needed are located in the central tip portion, see Fig. 38.

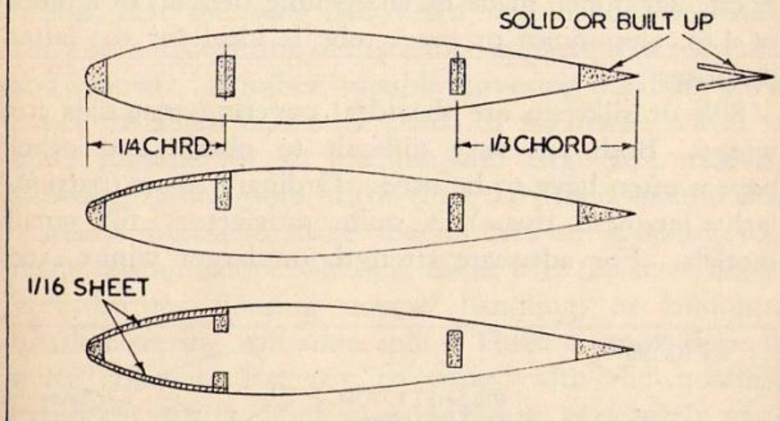
For the lead wires, 20 s.w.g. wire is generally adequate, but on larger models many designers prefer 18 s.w.g. Actually this is not necessary. The control lines themselves are very much thinner (and weaker) than 20 s.w.g. wire and there is really no point in having these lead wires excessively strong. The increased weight serves no useful purpose.

One disadvantage of small diameter lead wires is that under a heavy pull they tend to round off the control-

line loops to the diameter of the wire, which, if less than about twice the diameter of the control lines themselves, will weaken the loops and cause possible breakage. However, 20 s.w.g. wire as a minimum size is quite safe for use with all control lines of 30 s.w.g. size or smaller

Certain designs make a point of balancing the model laterally to ensure that the inboard wing is not excessively heavy which may tend to make the model drop a wing and slacken off the lines in high-level flight. Ballast weight is, therefore, added to the outboard wing tip to counterbalance the weight of the lead lines, see Fig. 39, enough weight being added to make the finished model balance level. In some cases excess ballast is added to

FIG 37 TWO-SPAR WINGS



the outer tip so that the outer wing has a natural tendency to drop. This has the effect of counteracting torque in a normal anti-clockwise circuit. From the point of view of stability in flight it is always better to have the outboard wing drop rather than the inboard, but ballast is not particularly effective in this respect and this practice is not widely used.

Ribs should be of quarter-grain sheet for maximum rigidity, where this is obtainable. Owing to the low aspect ratio of most stunt model wings the actual rib length is relatively large and, hence, fairly thick sheet is advisable. Small models can use $\frac{1}{16}$ in. sheet; medium sized jobs of between 175 and 300 sq. in., 3/32 in. sheet, and the larger models $\frac{1}{8}$ in. sheet. If in doubt, always use the large size sheet. Ribs from medium stock $\frac{1}{8}$ in. sheet may, in fact, be lighter than a similar set of ribs cut from hard 33/2 in. sheet and just as rigid.

Weight of the ribs is relatively low and there is no need to cut holes in them to lighten. Holes for the spars should be punched or cut out accurately, and also clearance holes for the lead wires, where this is necessary. A circular punch made by sharpening the end of a piece of $\frac{1}{4}$ in. aluminium or brass tube is ideal for the latter purpose.

Silk or silkspan are the ideal covering materials for wings. Both are very difficult to obtain and other papers often have to be used. Ordinary tissue (particularly Japanese tissue) is quite satisfactory for small models. For adequate strength on larger wings (300

FIG 38

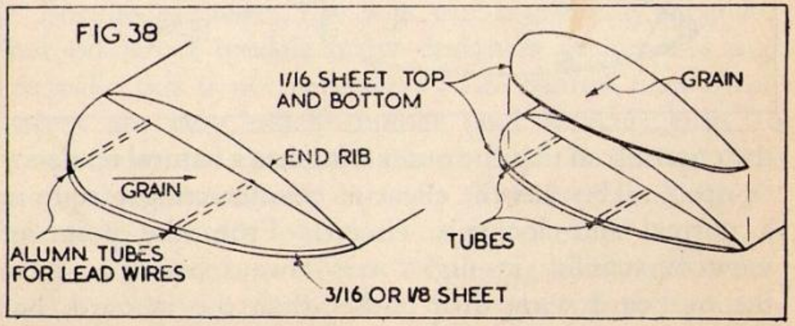
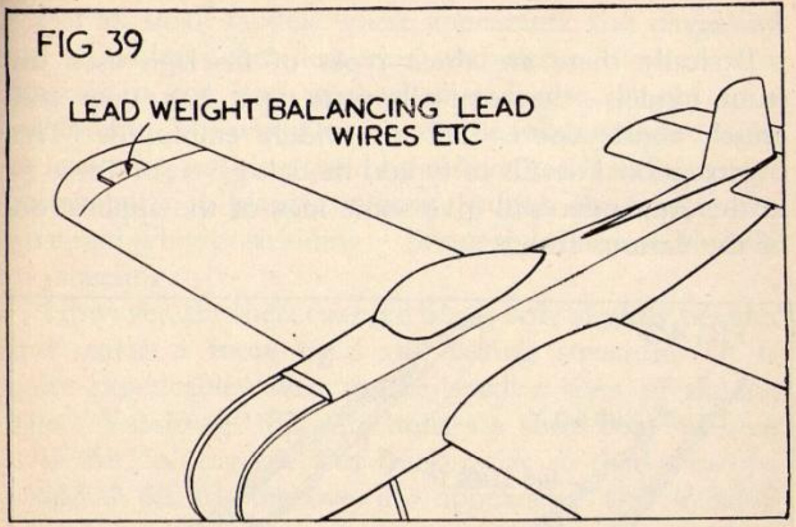


FIG 39



sq. in. and over) double covering should be used. This means, that the wing is covered and doped normally and a second covering of tissue then applied, water-shrunk and doped. Another suitable covering medium is a paper marketed under the name of rag tissue which is quite suitable for all medium and large size models, although rather more brittle than the others mentioned.

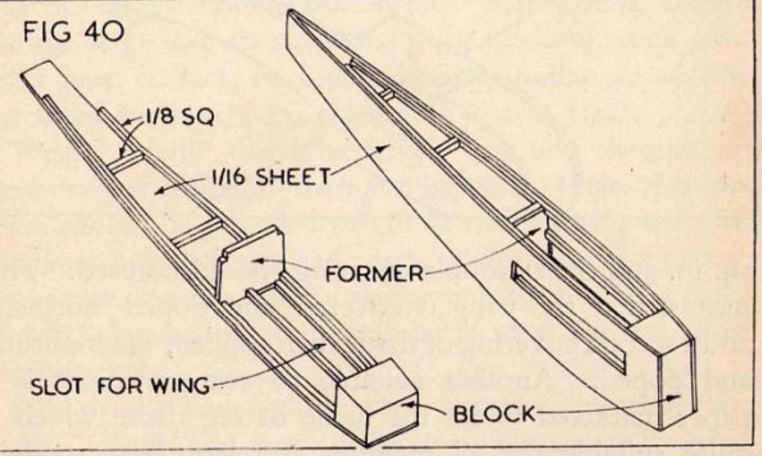
Many modellers make the mistake of applying too many coats of dope with the result that the covering is very brittle. During normal handling, or landings, brittle covering will soon split. Three coats of dope is quite adequate for any covering, with the possible exception of silk. Silk is, in any case, very rarely used on account of its high cost. Nylon has been used as a subsitute, but again cost is high.

Most dopes can be made more plastic by the addition of a small proportion of castor oil. Excessive castor oil must not be used as this will make the dope too flexible and also sticky.

Fuselages

Basically there are three types of fuselage used on stunt models—the semi-silhouette type, box type and crutch construction. All are widely employed. The constructional details of typical models given in Table E in the Appendix will give some idea of the application of the various forms.

FIG 40



There are no general rules which can be applied. Even the smallest models may use any of the three main methods, although the simple box fuselage is probably the lightest and most straightforward. These types have already been discussed in some detail in Book I.

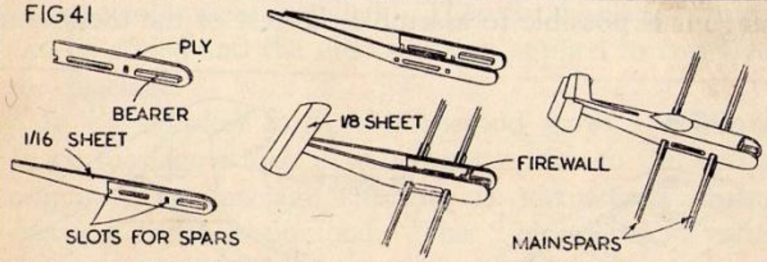
Allen's "Boxcar," Fig. 22, is typical of the elementary box-type fuselage with tissue covering, although it is more usual to find this type of construction confined to models of around the 150 sq. in. size. In this particular instance it has been recognised that this is the lightest possible form of structure and the model having been designed to have the lowest practical total weight, such construction has been adopted.

For all small models where appearance and durability are secondary considerations, the tissue covered box fuselage is the best method of reducing weight to a minimum. The wings may sit on the fuselage in the high- or low-wing position (held by rubber bands or cemented permanently in place), or pass through the fuselage to give mid-wing positioning. Strength is increased locally by sheeting.

However, the sheet covered box is only slightly heavier and makes a more rigid and lasting structure. It is quite practicable, even in the smaller sizes of model, The "Vandiver," Fig. 40, utilises a sheet covered box, with the decking sheet of thicker size so that it can be rounded off to improve the appearance and a cabin added.

This form of sheeted box is widely used on all sizes of model, right up to the very largest. For the small

FIG 41



and medium sizes, $\frac{1}{16}$ in. sheet sides are adequate, with or without internal longerons and spacers. The latter are used to support the sheet and make the structure more rigid. On the very large models, sides are generally $\frac{1}{8}$ in. sheet and the decking is built up with formers, then either sheet covered or tissue covered over stringers. This method is lighter than using a thick plank or block balsa for the decking.

Probably the majority of American stunt models of medium and large size are built in this manner and the Snafu " Magician," Fig. 41, affords an interesting example of how the fuselage is locally strengthened with ply to take the motor bearers and locate the wing spars. In other models where beam mounting is used the bearers are cemented to the balsa sides and then thoroughly braced to the structure with formers, the front former or firewall being of ply.

Crutch construction gives greater flexibility in regard to outline shape and the crutch itself forms an ideal datum to which all other components can be assembled and located. The " Dronette " and " Hot Rock," Figs 42 and 43, are typical examples of this method.

The crutch fuselage is very easy to build. The basic crutch is laid down directly over the fuselage plan and built up of large section wood. The motor bearers are spliced and cemented to the balsa crutch. At this stage it is possible to assemble the rest of the model on

FIG 42

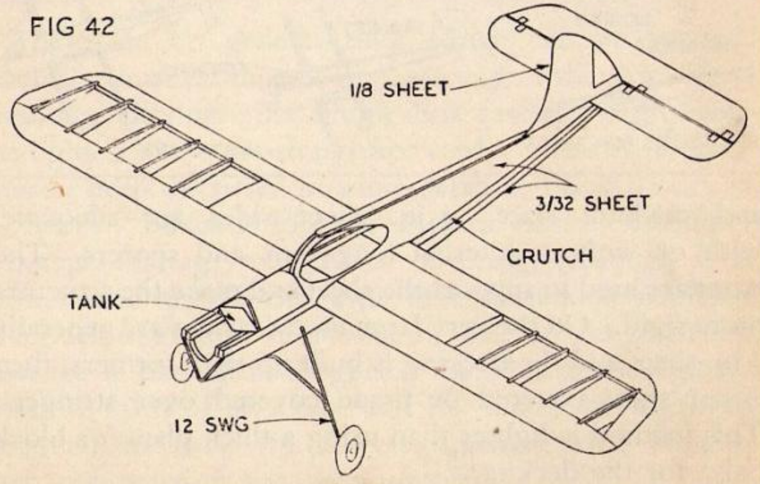
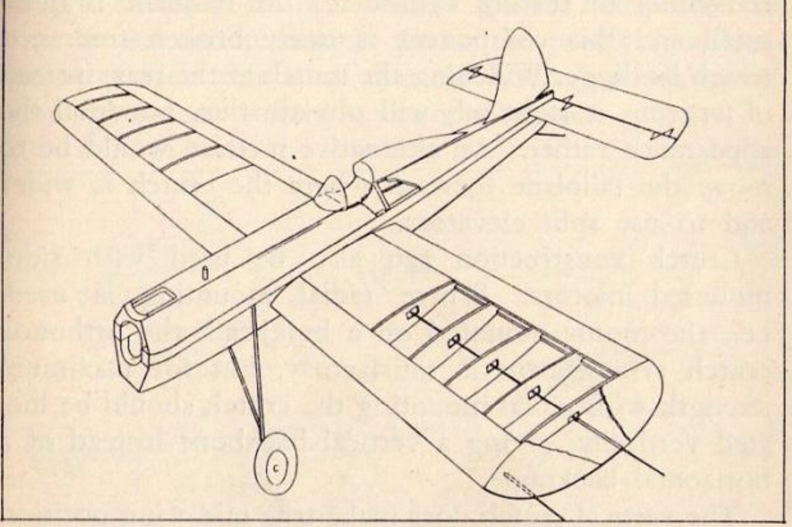


FIG 43 HOT ROCK



this crutch. The wings and tail unit can be located and the control system installed. Then the fuselage formers can be added and the final sheeting applied to complete the fuselage.

In its simplest form, this method gives a diamond shape fuselage which is quite robust, due to the strong crutch. The fuselage sheeting is virtually a fairing carrying little or no load. The " Hot Rock " varies the section somewhat by introducing wide top and bottom planks resulting in a hexagonal fuselage.

Using $\frac{1}{8}$ in. sheeting on medium-sized models with the actual joints backed up by stringers, the corners can be rounded right off to give a very pleasing appearance. On smaller models, $\frac{1}{16}$ in. sheeting is adequate.

Since the fuselage covering is virtually unstressed, the formers can be spaced widely. Their job is only to support the sheet without sagging. The one inherent weakness of this particular scheme is that the actual cementing or seating surface for the tailplane is quite small and this component is easily broken free in a rough landing. Widening the crutch at the rear, instead of tapering it right off, will obviate this, but spoil the appearance rather. An alternative method would be to move the tailplane forward where the crutch is wider and to use split elevators.

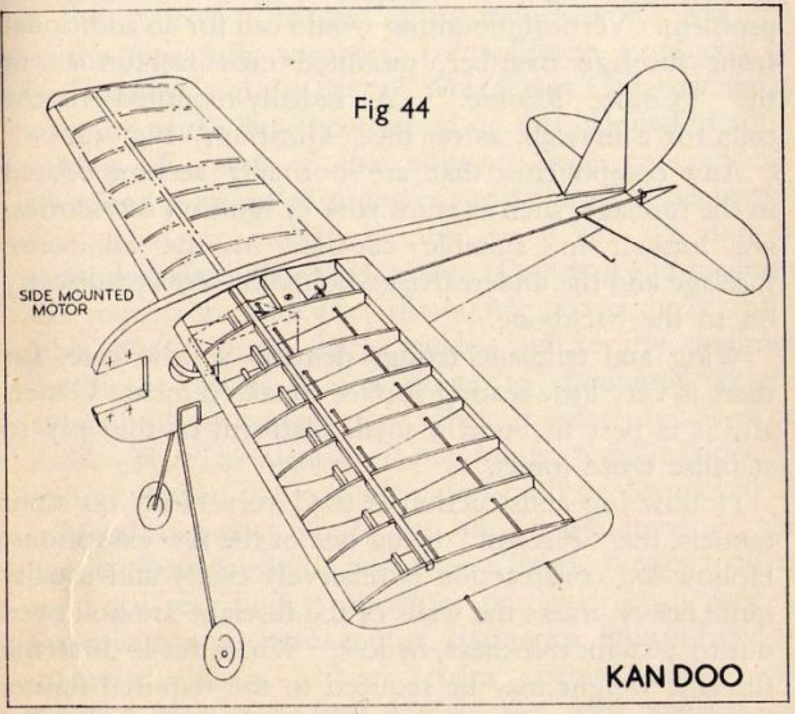
Crutch construction can also be used with side-mounted motors. Where radial mounting is used, i.e., the motor mounted on a bulkhead, the orthodox crutch arrangement is satisfactory, but for maximum strength with radial mounting the crutch should be located vertically, giving a vertical backbone instead of a horizontal backbone.

The vertical crutch does make true mid-wing position possible, the wing passing right through the centre of the crutch, but a more rigid form of fuselage construction is needed in this region and in the area of the tailplane seating. Formers of adequate proportion will provide this, these formers being secured strongly to the main crutch member. Sheeting is then applied as before to complete the fuselage structure and stiffen the whole. With vertical crutch construction the fuselage sheeting does, in fact, contribute materially towards the strength of the model.

Crutch construction is best suited to medium size models of 250 to 350 sq. in. in area. It has been used successfully on both smaller and larger types, e.g., the "Playboy" series, 30-in. span and 50-in. span, but in such cases one of the variations of the simple box fuselage generally is used.

The semi-silhouette stunt model is typified by Pete Cock's 1948 Nationals winner (Fig. 44), and the

"Stuntmaster" (Fig. 7), where the fuselage is simply a rigid structure to locate wings and tail and mount the motor and undercarriage. From the purely functional point of view this is all that the fuselage needs to do, but appearance suffers as a consequence.



Nevertheless, this type of model is extremely robust for the fuselage is virtually indestructible, particularly if made of ply as in the case of the "Kan-Doo." More and more models of this type are appearing, both for training and for actual contest flying.

The silhouette fuselage can be of ply (suitably lightened by cutting out holes, covering with tissue or thin sheet balsa), or mixed balsa and ply construction. That part of the fuselage on to which the motor is bolted must be of ply, or at least ply faced either side. It is quite useless to attempt to bolt a motor directly on to balsa.

Most semi-silhouette models use a side-mounted motor, this being the simplest way of tackling the problem. Vertical mounting would call for an additional front fuselage member, mounted cross-fashion as in the "Comet Rookie." A radially-mounted motor calls for a firewall, as on the "Glo-Bug," Fig. 34.

Any components that are normally accommodated in the fuselage, such as stunt tank or ignition accessories, are located in suitable cut-outs in the silhouette fuselage and the undercarriage bolted or screwed directly on to the backbone.

Wing and tailplane fixings demand a little care, for there is very little seating surface to take cement. Generally it is best to build a small platform of thin ply to stabilise these joints.

Hollow log construction is used very rarely on stunt models, the "Fireball" being one of the few exceptions. Hollow-log construction is relatively costly and usually quite heavy unless the walls of the fuselage are hollowed out to 3/16 in. thickness, or less. When this is done the fuselage weight may be reduced to the required figure, but the resulting structure is weak, particularly locally, as compared with the other methods.

Tailplane and Elevators

The usual practice is to employ solid construction for both tailplane and elevators, ⅛ in. sheet for the smaller models, 3/16 in. for medium size jobs, and ¼ in. sheet for the largest. This is generally satisfactory, easy to make and quite durable. Plywood sheet has been used

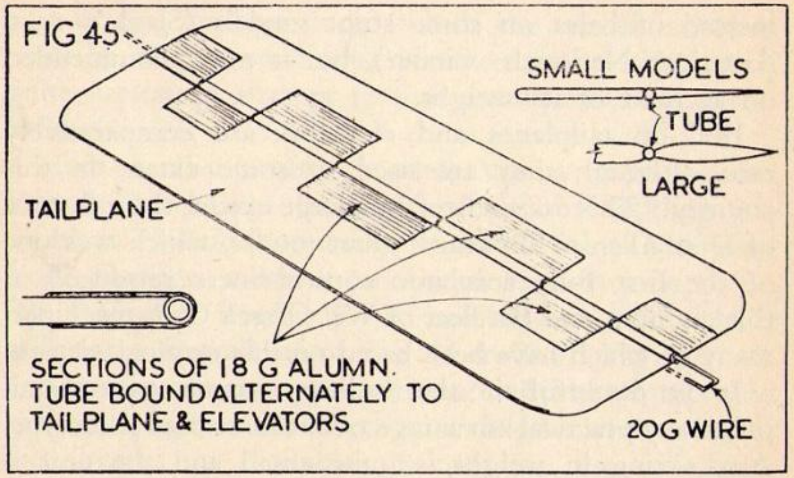
instead of balsa on some stunt models (Slagle's 1946 American Nationals winner), but is not recommended on account of its weight.

Built-up tailplanes and elevators are comparatively rare, although they are used to some extent in this country. This does reflect, to a large extent, the influence of Den Allen's "Boxcar" stunt model, which was one of the first fully aerobatic control-liners produced in this country, and the fleet of West Essex Club machines, many of which have been based on this original design.

It is doubtful if the built-up tissue-covered tail offers any practical advantage over the normal sheet type. Any saving in weight is quite small and the unit is certainly more prone to damage. On small and medium size models in particular, the saving in weight is negligible. Only in the large models where the designer specifically wants to get down to minimum weight would built-up construction appear to offer any advantge at all. Here, as mentioned previously, weight is not so critical, and so the possible gain is still problematical.

Metal elevator hinges are to be preferred to the conventional fabric or tape type. Fabric hinges tend to fray and tear under vibration, particularly on models fitted with a powerful motor, also fabric hinges have an inherent stiffness. Metal hinges operate much more freely. However, tape hinges are still retained on many models for the sake of simplicity, but if this is done the hinges should be fitted the full span of the tail as on the "Snafu Magician," when the failure of one or more hinges will not be serious.

The other part of the tail unit—the fin—is to all intents and purposes quite separate, but construction is very similar. Sheet balsa of similar thickness to the tailplane is generally adequate, with possibly thicker,

FIG 45


laminated sections of the larger models. The main thing is to make a very secure anchorage to the fuselage so that the fin will not fall off under motor vibration, this in particular applying to the rudder portion. The rudder is permanently offset some 15 deg against the flight circle on most models, the best position being found by test flying. Excessive offset should be avoided, only that necessary to maintain line tension in high altitude flight being used. A small tab with large offset is far less effective than a larger tab with smaller offset. Excessive offset will only stall the rudder with consequent loss of efficiency. Moderate offset on the whole fin is quite effective (see " Boxcar").

Landing Gear

Suitable undercarriages are detailed in Book I, including drop-out types. The latter, as mentioned previously, are used generally on small models where the decrease in drag and weight resulting from jettisoning the unit after take-off materially improves performance.

With a fixed undercarriage, a good fixing is essential, the top of the legs being located to a hardwood member (such as the firewall or motor bearers). Keep the unit as light as possible and use only that gauge wire necessary for rigidity. Excessively large wire is quite unnecessary and adds considerable excess weight.

It will be found that on the larger and heavier models a spreader bar is an excellent method of stabilising the undercarriage, making a reasonably rigid unit with relatively small section wire for the legs. The spreader bar should be located well clear of the ground so that it will not foul the grass during a take off from such surfaces.

A wide variety of streamlined rubber wheels are available, the weight of which is not excessive even on most of the smaller models. Wood wheels are lighter, but require stout metal bushings to run properly, and are always liable to split in half in a heavy landing. Always make sure that the wheels run truly on the stub axles and also that the retaining washer or collect is well and truly secured to the axle. Shedding a wheel during landing or take off may result in damage to the model as it will inevitably turn over on to its back.

Normally some sort of tail skid should be used, securely located in the fuselage. On large models a tail wheel is helpful. Main use of the tailskid is in keeping the tail of the model off the ground. On many models with no skid the elevators actually touch the ground with the model at rest and may be damaged or the control horn bent, upsetting the control system, when starting the motor.

CHAPTER V

MOTORS

More than any other branch of power flying, successful control-line work demands a powerful motor. A motor which may run quite smoothly and consistently at moderate r.p.m. is very rarely good enough. Both stunt and speed models demand the maximum possible power for a given size and weight of power plant and unless this power is available, performance will be very mediocre.

Stunt models originated in America and as we have seen in previous chapters the first designs of this class were large jobs of between 400 and 500 sq. in. wing area. Only the more powerful of the 10 c.c. class of spark-ignition motor was suitable and one of the first accepted stunt motors was the " Super Cyclone." This is a fairly orthodox spark-ignition motor, but very powerful for its size. It has a relatively long stroke, but a normal operating r.p.m. of at least 8,000. This became, in fact, one of the criteria for a successful stunt motor, a minimum r.p.m. of around the 8,000 mark.

In the same class, but not so powerful, is the well-known " Ohlsson 60." This is a " workhorse " of a motor, very reliable and with a good turn of speed. It has been used successfully on many control-liners of maximum size with good results, but gives its best performance on machines of a similar size to the " Box-car " with a relatively light wing loading.

For the large American stunt models, more and more powerful 10 c.c. motors have appeared. The " Attwood Champion " established itself by powering the winning

model in the 1947 Nationals and further developments of this motor in other sizes have proved equally successful. Also in the 10 c.c. class the " Anderson Spitfire " has proved outstanding, whilst for even more power the " Orwick 64," of slightly larger capacity (10.5 c.c.) is much favoured.

Now none of these motors develops the maximum possible power for its class. The purely racing motors such as the " McCoy," " Hornet " and " Dooling," all develop more than 1 h.p. at speeds in excess of 15,000 (i.e. maximum operating efficiency). Since these racing motors only develop their amazing power at extremely high r.p.m., they are basically unsuited for stunt work and so we get the two distinct classes of motors for control-line models.

The high speed racing motor is in a class of its own. It can, and has, been used on stunt models, but to get the power required it means flying the model at very high speeds and making the pilot's job much harder and greatly increasing the possibility of a crash. High speed stunt flying may be spectacular, but this is certainly not the best way to go about it.

The stunt motors are generally characterised by a longer stroke, which inherently limits the ultimate r.p.m. and are developed to deliver their maximum power at speeds of between 7,500 and 10,000 r.p.m. This itself is quite fast, faster in fact than the best miniature aero-motors of seven or eight years ago, but, coupled with the correct propeller, reduces the flying speed of the model to reasonable proportions. A good stunt motor, incidentally, generally makes a good free flight contest motor (with a different propeller) and most manufacturers specify that their particular motor is either a stunt and free flight motor, or a racing motor.

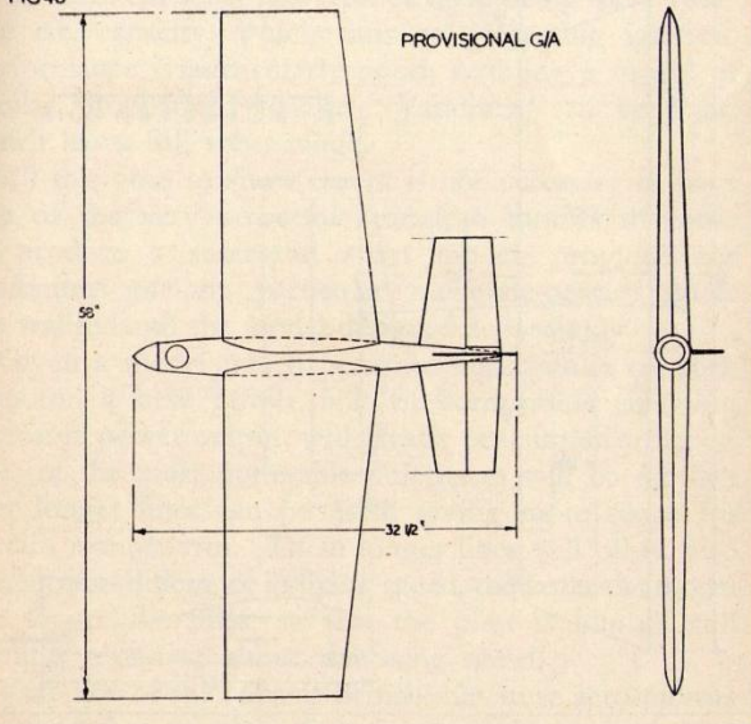
Plenty of power means greater latitude in design, which is one of the reasons why a large control-liner can have a heavier wing loading than a small control-liner for the same range of aerobatics. The general rule is, where the maximum power is not available use a model with a lighter wing loading. Thus in the case of a 450 sq. in. prototype which originally specified a "Super Cyclone" or "Attwood Champion," motor, but is actually to be used with an "Ohlsson '60'" the whole machine will have to be lightened to get a comparable performance with the less powerful motor.

With the introduction of the smaller classes of stunt models it became apparent that only the most powerful of the small motors would give optimum performance. Yet at the same time, by reducing the wing loading to quite a small figure small motors with moderate power could be used successfully.

A typical example is the Mills diesel, of 1.3 c.c. capacity. This is one of the standard British diesels which can correctly be classed as having a moderate power. It is certainly not exceptionally powerful, neither is it in the low power class. Yet by designing the model to suit the motor some very successful Mills-powered stunt control-liners have been produced which are capable of "everything in the book." This feat was thought impossible at the beginning of 1948.

The "Millsbomb," was one of the first successful moderate-power stunt models to appear, and it has shown itself readily capable of most advanced manoeuvres. This particular model, however, will not perform consecutive loops. For the size of model (necessary to reduce the wing loading) the power is just not available at the bottom of one loop to take it over the next. Consecutive horizontal eights are another

FIG 46



matter, the "Millsbomb" will perform this *ad infinitum*.

Mills-powered stunt models with a full aerobatic range now tend towards the modern short-moment layout as typified by the Stuntwagon—Fig. 46—although of course, considerably smaller in size.

Since the "Millsbomb," smaller and even lighter models have appeared, around the same motor with a more extensive stunt range, one of the best examples being R. Prentice's model, shown in Fig. 47, where the airframe is lightened to a degree.

As another typical example, the "E-D Comp. Special"

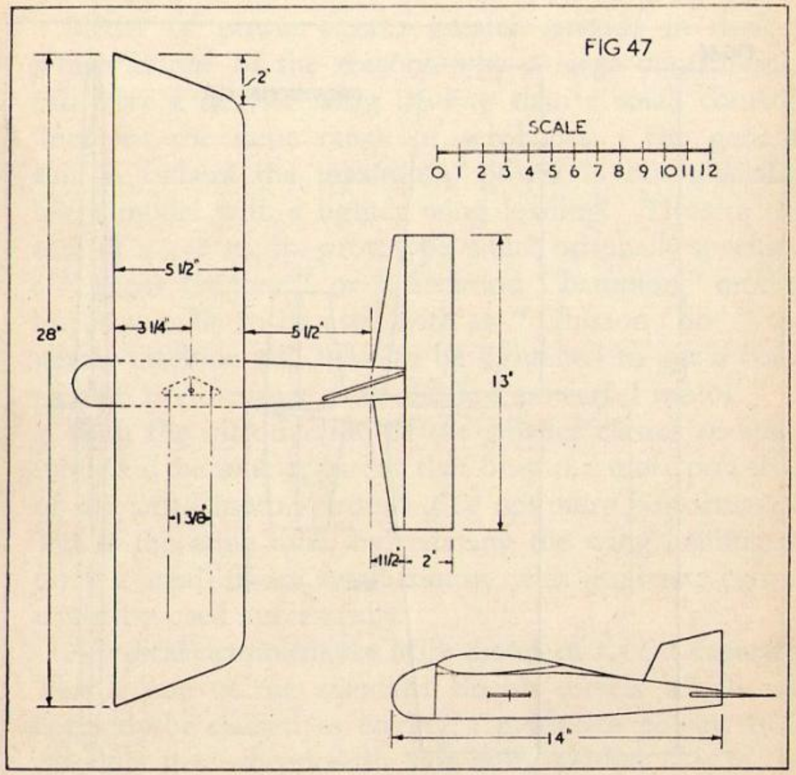


FIG 47

is a standard 2 c.c. diesel for which no outstanding power performance figures are available. A stock "E-D Comp. Special" can be expected to turn out between 5-6,000 r.p.m. with a 9 in. diameter 8 in. pitch propeller, or 7-8,000 r.p.m. with a 10 in. diameter 6 in. pitch propeller, excellent figures, but not exceptional, Furthermore, the E-D diesel is not particularly light, bare weight being 6½ oz.

Yet a stock E-D motor powered the model to win the 1948 Nationals stunt event, the "Kan-Doo," and has proved equally successful in similar models.

The "Frog" series of motors has already been mentioned, the most powerful of these being the "160" (1.6 c.c. capacity) which runs on glow-plug ignition. Performance is particularly good, enabling a model of similar proportions to the "Vandiver" to be built, which has a full stunt range.

All this goes to show that it is not necessary to have one of the very powerful American motors in order to produce a successful stunt model, provided the limitations of any particular moderate-power motor are realised and the model designed accordingly.

Given a model which performs successfully on such a motor, a new power unit of comparable size, but increased power output, will greatly benefit performance. One of the most noticeable differences will be the fact that longer lines can be used, giving more scope for certain manoeuvres. These longer lines will offset also the effect of difference in flying speed, the faster the model the longer the lines, so that the pilot is himself still turning round at about the same speed.

Very few of the current British miniature aero-motors in production can claim to be in the high-powered class. Examples are appearing, the "Elfin" 1.8 c.c. diesel is one. Used as a replacement for a standard motor of similar or slightly smaller size on a quite successful stunt model the difference in performance is most marked. The original "Playboy 30," for example, is extremely lively with an "Elfin" diesel and will fly and stunt quite happily on 55 ft. lines.

American manufacturers produce quite a number of high-powered motors in the smaller sizes, notably the "Arden" (1.6 c.c. and 3.2 c.c.), "Bantam" (3.2 c.c.), the "Forster 29," "Torpedo," etc. (5 c.c.) and the new "Ohlsson '23'" with rotary valve. All of these motors run successfully on glow-plug ignition and are generally used in this fashion on small stunt models. Figures for bare weight of most American motors are usually very good, but if ignition accessories and flight batteries have to be added the total operating weight is higher than is desirable. Hence the trend to go over to glow-plug running so that the total power unit weight is very favourable compared with that of a diesel of similar capacity. Almost without exception, too, such motors are considerably more powerful than their diesel counterparts.

Some motors are, unfortunately, virtually useless for successful control line stunt work. Even in a lightly loaded model of correct proportions they have all their work cut out to keep the model airborne, let alone attempt manoeuvres. It is obviously not possible to list unsuitable types in print, even though they may be excellent in other respects and well suited for free flight models for which they were, in any case, originally intended. Personal experience is the best guide, or follow what the leading experts are doing. If an authority on control-line flying uses a particular motor extensively it is a pretty sure recommendation that this motor is well suited for the work.

Diesels have the advantage of being self-contained, and good diesels are very seldom critical as regards fuel mixture. Most will operate successfully on quite a range of fuel mixtures, the main difference being that in some cases starting is more difficult and that some mixtures will give more power than others. Unless one is prepared to experiment at length, there is little to be gained in using other than recommended fuel as specified in the maker's instruction manual, or commercial blended fuel suited to that particular motor. From the point of view of economy

it is always much cheaper to mix one's own fuels, but often some of the ingredients are extremely difficult to obtain. Also specifications may differ widely for substances having the same general name. Consistent results are best obtained by using one brand or type of fuel most suited to a particular motor and sticking to it.

Diesels of up to 5 c.c. are now used widely in stunt control-liners. Some of the best 5 c.c. diesels have a power output comparable with many of the average 10 c.c. spark-ignition motors and develop more than enough power for models up to as large as 300 sq. in. area. The one American diesel which has achieved popularity—the " Drone "—is particularly outstanding and is almost a standard stunt model motor. It has gained many notable successes, including a first at the 1947 Nationals (Tucker's "Hot Rock") and first and other places in numerous other events.

Comparable with the very best of the diesels, but generally developing considerably more power, the specialised glow-plug motor is now coming into use (as distinct from glow-plug conversions of standard spark-ignition motors), of which the " McCoy Sportsman " is an outstanding example. This is a design developed directly from the already famous " McCoy " series of racing motors, the " Sportsman " exemplifying the remarks at the beginning of this chapter that a motor developing peak power below racing r.p.m. is necessary for stunt work. Even so the " Sportsman " is a very fast motor with exceptional power and the relative beginner, at least, may find a model so powered rather " hot " to handle.

Of the British glow-plug motors the " Frog 160 " has been developed from the " 100 " and " 180 " and is again quite fast. It is more or less an ideal power plant for models of the size of the " Vandiver." Currently, other British glow-plug motors are modifications of existing spark-ignition or diesel motors.

Glow-plug motors have reached the stage where they are extremely reliable and a good glow-plug motor develops at least equivalent power to its spark-ignition counterpart without the extra weight of ignition and flight batteries. This is very important where the smaller models are concerned. Operating cost is rather high by comparison, particularly where doped fuels are used. The cost of commercial fuels compares fairly well with diesel operation, although fuel consumption is higher than either petrol or diesel operation. Some glow-plug motors will operate quite successfully on ordinary mixtures of castor oil and methanol (or even petrol and oil), but nitro-methane, nitropropane, nitro-benzine or similar additives make for smoother running, easier starting and greater power output. Unfortunately, all of these latter substances are both difficult to obtain and extremely expensive—hence the relatively high cost of commercial blended fuels.

Where methanol fuels are used—either with glow-plug or spark-ignition—the doped surface of the model must be " proofed," otherwise excess fuel thrown out of the exhausts will attack the cellulose (dope) finish. Suitable proofing agents are marketed under the name of " hot fuel proofer," one coat of which generally is sufficient to afford complete protection.

The beginner to control-line stunt flying is thus faced with several problems which revolve around the power plant itself. If he favours the larger type of model then, for economic and trouble-free running, one of the larger (10 c.c.) spark-ignition motors comparable with the " Super Cyclone " or even the " Ohlsson '60' " will be

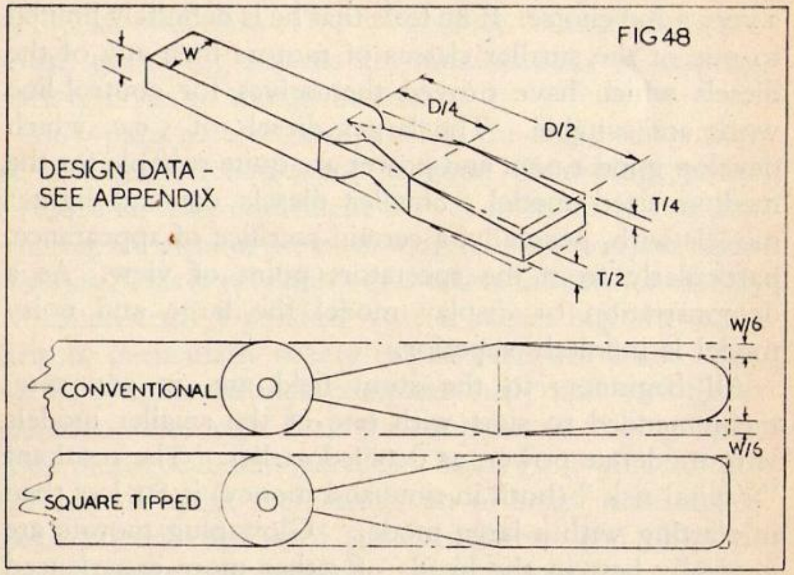
a very good choice. If he feels that he is definitely limited to one of the smaller classes of motors then any of the diesels which have proved themselves for control-line work are suitable. The larger diesels of 5 c.c. which develop good r.p.m. and power are quite suitable for the medium-sized model. Smaller diesels demand lighter models with, generally, a certain sacrifice of appearance, particularly from the spectators point of view. As a demonstration or display model the large and noisy model is infinitely superior.

All beginners to the stunt field are, in any case, recommended to start with one of the smaller models with moderate power, as detailed earlier. The resultant " capital risk " (both in time and money) is far less than in starting with a large model. Glow-plug motors are generally best in the hands of rather more experienced modellers.

The first check on any motor is its r.p.m. output. If the motor will not deliver more than about 6-7,000 r.p.m. with the specified control line propeller it is highly probable that it will not develop enough thrust for satisfactory stunt work. This is a very elementary rule, but failing costly and elaborate test apparatus, rule-of-thumb methods must be used and, generally, give reasonably reliable results.

Propellers for control-line stunt work are invariably of smaller diameter than for free flight, and usually have greater pitch. Most manufacturers now specify suitable propeller sizes for their motors and a wide range of commercial propellers are available in different pitch and diameter sizes.

Regarding the latter, it is unfortunate that the pitch sizes specified by propeller manufacturers are seldom accurate. Almost invariably the actual geometric



pitch of a commercial propeller is less than that specified. Thus motor " A " is said to require a propeller of 10 in. diameter and 6 in. pitch. A commercial propeller of this (quoted) pitch may have an *actual* pitch of only 4 in., and a 10-8 in. pitch quoted may have the required actual pitch of 6 in.

In any case some experimentation will be necessary to determine the best pitch for any new model; a slight change in pitch may often make a considerable difference to the flight. The tendency is to use too fine a pitch with the result that the motor races at high speed with the model flying relatively slowly. In such cases an increase in pitch frequently gives increased thrust, although increasing the pitch too much will have the opposite effect. Change in diameter has less effect than change in pitch, although change in *blade area* may make a considerable difference to the thrust.

Some authorities recommend propeller blades of fairly generous area for stunt work, with blunt or semi-circular tips rather than the narrow, tapered blades commonly used. Parallel chord blades are, in fact, quite effective at moderate speeds, although whether there is any marked superiority over conventional shapes is still a matter of some doubt. One generalisation is true, and that is that thin blades are better than thick sections. A polished surface also increases efficiency.

As a general guide the following table gives recommended propeller proportions for stunt work for various typical motors. Fig. 48 details blank proportions for carving propellers of approximately constant geometric pitch with conventional and parallel-chord blades.

TABLE V

Motor	*Capacity*	*Propeller*	
	c.c.	*Diam. in.*	*Pitch in.*
Frog 100	1.0	8	4
Mills I	1.3	8	5
Mills II	1.3	8	5-6
Frog 160	1.6	8-9	4-5
Arden .099	1.6	8	6-8
Frog 180	1.66	8	6
Elfin	1.8	8-9	6
E-D Comp. Special ...	2.0	9	8
Arden .199	3.25	9	8
Bantam	3.25	9	6
Ohlsson 23	3.75	9-10	6-8
Torpedo	4.9	8-11	10-6
Forster 29	4.9	9-11	8-6
Vulture	5.0	9-10	8-6
Drone	5.0	9-14	8-4
Sportsman Jnr. ...	5.9	8-9	8-8
Sportsman Snr. ...	9.0	10-11	8-8
Ohlsson 60	10.0	10-12	8-6
Super Cyclone ...	10.0	12-14	10-6
Attwood Champion...	10.0	12	8

With few exceptions, the most logical way of mounting a motor is upright, since this minimises the risk of flooding and, in the case of spark- and glow-plug ignition, keeps the plug as dry as possible during the starting period. Some diesels, however, run best in the inverted position, e.g. the "Frog" series.

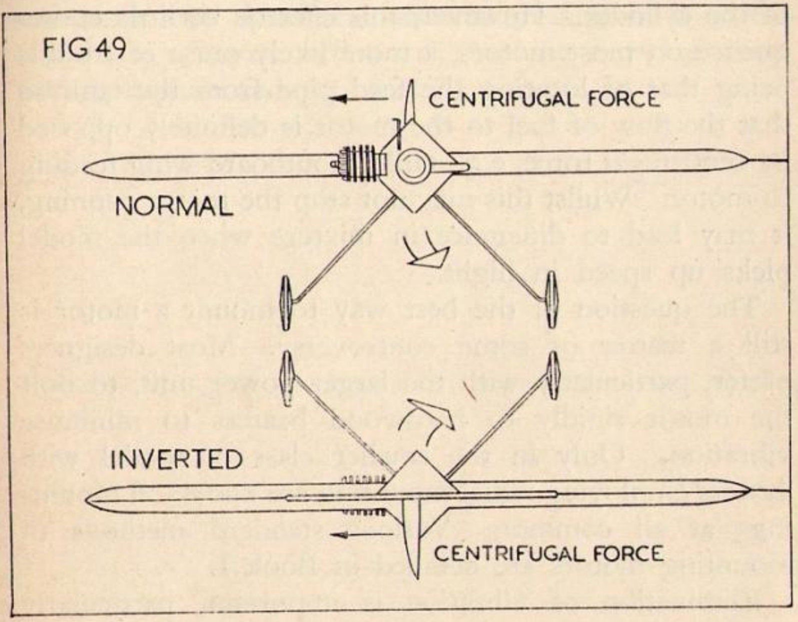
From a purely practical point of view side mounting of a motor reduces its vulnerability in the event of a crash landing. With a vertically mounted motor in inverted flight the cylinder is projecting downwards and will receive the full force of the impact in a crash landing. In many cases a stunt model does have to be landed in the inverted position. As an example, the motor may cut out or fade after the model has been taken over to the inverted position. Without ample power, recovery to normal flight is quite impossible and the only thing to do is to land the model upside down.

Side-mounting is, if anything, favoured more in this country than in America, and is now widely used on all classes of models. Almost any motor will run in such a position provided the correct tank system is installed.

In flight, the side mounted motor is subjected to centrifugal force so that, with the cylinder pointed outwards (the normal way) conditions are equivalent to static inverted running and conversely if the cylinder is pointed inwards. Either way is, in fact, usually satisfactory, although it is more usual to have the cylinder sticking out away from the centre of the circle.

In certain cases this effect is used to obviate the necessity of a special tank. "Frog" motors are fitted with an integral tank and, if side-mounted and pointing outwards, conditions in flight are similar to normal inverted running, whether the model is upright or

inverted. Centrifugal force in this case takes the place of gravity. Thus a side-mounted motor of this type can be used for stunt work without further modification of the fuel feed. (Fig. 49.) The only thing is that the model must be held on its side for starting, i.e., in the normal inverted position and placed level only when



ready for take off. Take off must be rapid to build up the necessary speed generating sufficient centrifugal force to restore normal operating conditions.

This method works extremely well in practice. If, in addition, the fuel feed pipe is taken around the motor in a loop between the tank outlet and the needle valve the motor will run static for 10 sec. or so in the horizontal position, the amount of fuel retained in the pipe being sufficient for this.

In many cases it will be possible to mount motors with the cylinder facing inwards towards the centre of the circle. With some motors, in fact, this may be preferable. Centrifugal force is here opposing the flow of fuel from the crankcase to the top of the cylinder; with side-mounted motors facing outwards centrifugal force is assisting the fuel flow from crankcase to the top of the cylinder. However, this effect is of little consequence on most motors, a more likely cause of trouble being that of locating the feed pipe from the tank so that the flow of fuel to the motor is definitely opposed by centrifugal force, e.g., tank in outboard wing feeding to motor. Whilst this may not stop the motor running, it may lead to difference in mixture when the model picks up speed in flight.

The question of the best way to mount a motor is still a matter of some controversy. Most designers prefer, particularly with the larger power unit, to bolt the motor rigidly to hardwood bearers to minimise vibration. Only in the smaller class of model with motors employing radial mounting are knock-off mountings at all common. Various standard methods of mounting motors are detailed in Book I.

Elimination of vibration is important, particularly on diesel and glow-plug motors. These types have a definite tendency to run "rough" if out of adjustment and vibration may cause just this. Further, motor vibration is transmitted to the airframe and thence to the control lines. It is not unknown for models which vibrate excessively to snag the control lines through vibration winding them together, with consequent loss of control. In other cases, motor vibration has led to tail flutter and again loss of control.

In mounting a motor, lock nuts should be used on all

bolts and tightened right down. Whenever possible, these nuts should be inspected frequently to make sure that they have not worked loose. Once one nut has slackened off it is quite probable that the others will follow suit.

Many cases of vibration can be traced to an unbalanced propeller. Operating at quite high r.p.m. even slight unbalance can upset the smooth running of a motor and this is a feature well worth checking if undue vibration is experienced.

CHAPTER VI

TANKS

SATISFACTORY fuel supply is absolutely essential for a stunt model and to obtain this whatever the attitude of the model one of the several forms of stunt tanks are generally used. Several commercial types are available which are quite satisfactory for general use, but home made tanks are often preferred when they can be shaped to fit the actual fuselage of the model. The very best of commercial tanks is of little use if it is too large or too bulky to be accommodated within the fuselage.

For anyone handy with a soldering iron the construction of a suitable tank is relatively easy. Tinplate or thin sheet copper or brass are the ideal materials for construction. All solder readily, and the thin sheet material can be cut and trimmed with scissors. Thickness of the sheet material should be between 0.010 and 0.015 in.

In assembling a metal tank, an acid flux must be used and all parts to be soldered well cleaned. After completion, it is essential to wash out the tank thoroughly to clean out any surplus flux. Acid flux makes the best job, but is also corrosive and free acid left in the tank will corrode any of the metals mentioned. There is also the danger of some acid actually entering the motor, where its corrosive action can be disastrous

It is also necessary to finish the tank *completely* in one soldering operation. *Never* attempt a re-soldering job on a tank which has been filled with fuel. A damaged tank is best scrapped and another one built. Also any lugs or similar fittings necessary for mounting the tank

in the model should be added before filling with fuel. It is virtually impossible to thoroughly free a tank from fuel and even the fumes remaining in an apparently empty tank may lead to an explosion. For this reason it is best to test a tank with water to prove against leaks after completion. Then if a leak does show up the tank can simply be emptied and re-soldered as necessary with no risk. In full size practice very elaborate precautions are taken to free a fuel tank from fumes before attempting any welding or similar repairs, and this is not possible in the home workshop.

In flight, the fuel in the tank is subjected to three main forces—centrifugal force, inertia and gravity. The object in the design of a stunt tank is to normalise the action of these as far as possible, so that whatever the speed or attitude of the model the actual " head " of fuel is virtually constant.

With the model stationary, Fig. 50, the " head " or suction lift is defined clearly (suction lift being the vertical distance the suction of the motor has to lift the fuel to the needle valve). Now as soon as the model is in motion the fuel tends to flow to the outside of the tank under the action of centrifugal force, reducing the actual suction lift distance and affecting the *quantity* of the fuel supply. All other conditions being constant this would, in fact, tend to richen up the motor. If the fuel pipe were located centrally or to the inboard side of the tank the fuel supply to the motor would cease quickly, even though considerable fuel may remain in the tank.

Ignoring for the moment the variation in suction lift, it is obvious that the fuel line must be taken from the outboard side of the tank and this is one of the features common to all stunt tank design.

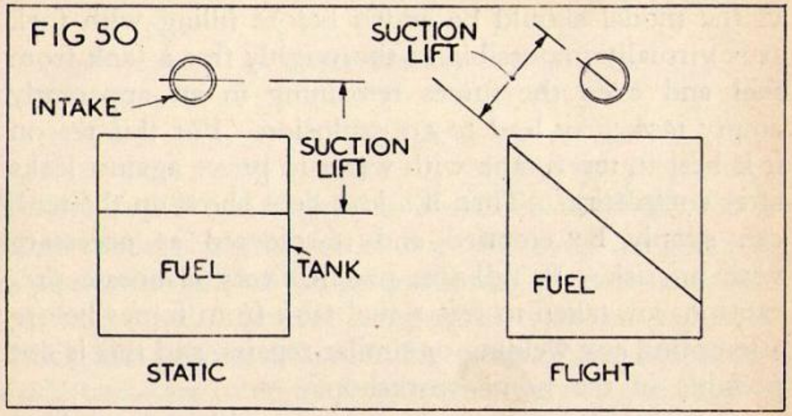


FIG 50

Consider now the effect of inverting the model whilst in flight, Fig. 51. In normal level flight with the tank below the needle valve the suction lift is negative, i.e., the motor must do work to lift the fuel from the tank to the needle valve. With this arrangement inverted

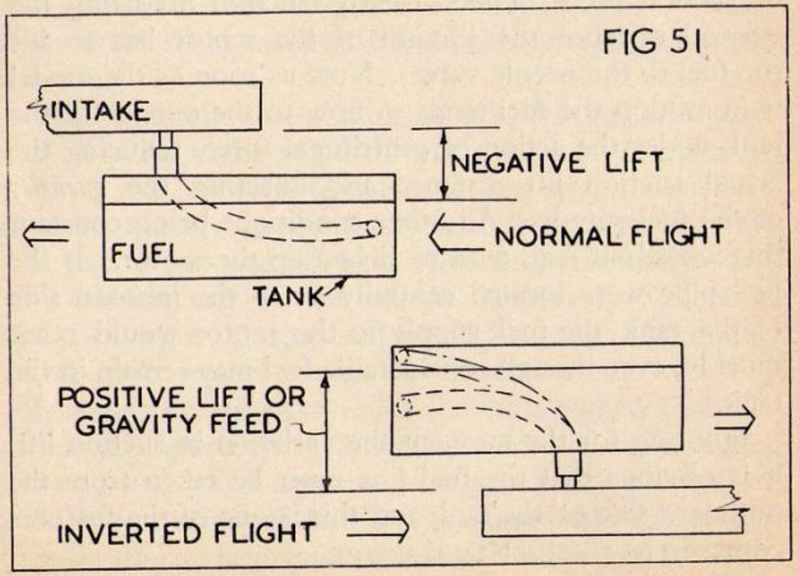


FIG 51

the suction lift becomes *positive*, or in other words the motor is now gravity fed. The quantity of fuel approaching the needle valve will increase, tending to richen up the mixture. Also unless the feed pipe is correctly positioned the fuel supply will cease.

For example, the logical place to locate the feed pipe for normal level flight is at the bottom of the tank,

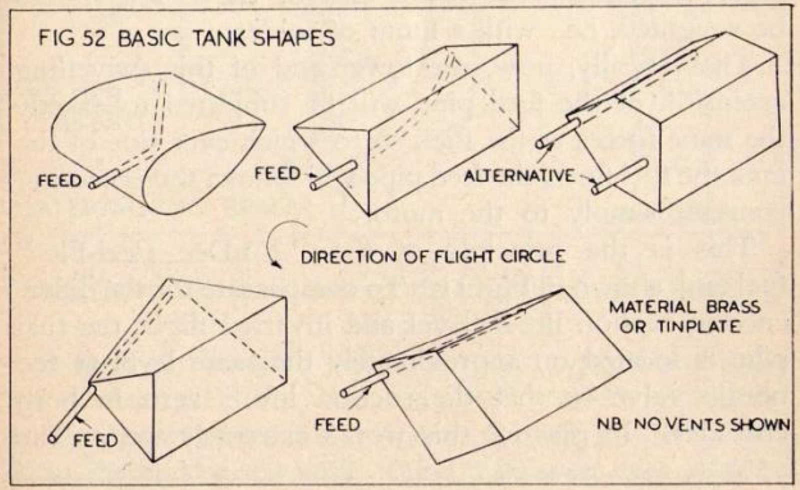


FIG 52 BASIC TANK SHAPES

but when inverted this pipe would be clear of the fuel, starving out the motor. Central location is the obvious compromise, but in this case neither in normal nor inverted flight will the tank ever be more than half emptied.

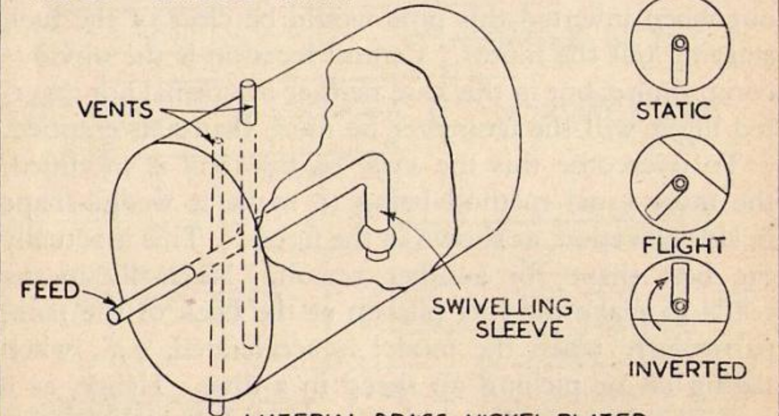
To overcome this the *shape* of the tank is modified, the most usual method being to make it wedge-shape in side elevation, as shown in the figure. This is actually the best shape for another reason. Normally inertia tends to make the fuel pile up at the back of the tank, particularly when the model is accelerated, e.g., when taking off or picking up speed in a dive. Hence, as a general rule the fuel tends to flow towards the rear outside corner of the tank, which is obviously the best point to locate the feed pipe. Some typical shapes illustrating this principle are shown in Fig. 52.

There is another very clever type of tank which tackles the problem in a different way. The fuel pipe is located centrally and taken to the rear of the tank, but fitted with a T-shaped sleeve which is free to swivel on the main feed pipe. Preferably the lower end of the " T " should be weighted, i.e., with a lump of solder.

Theoretically, now, the lower end of this swivelling extension of the feed pipe will be subjected to exactly the same forces as the fuel, so to which ever side of the tank the fuel flows the feed pipe will follow, thus ensuring constant supply to the motor.

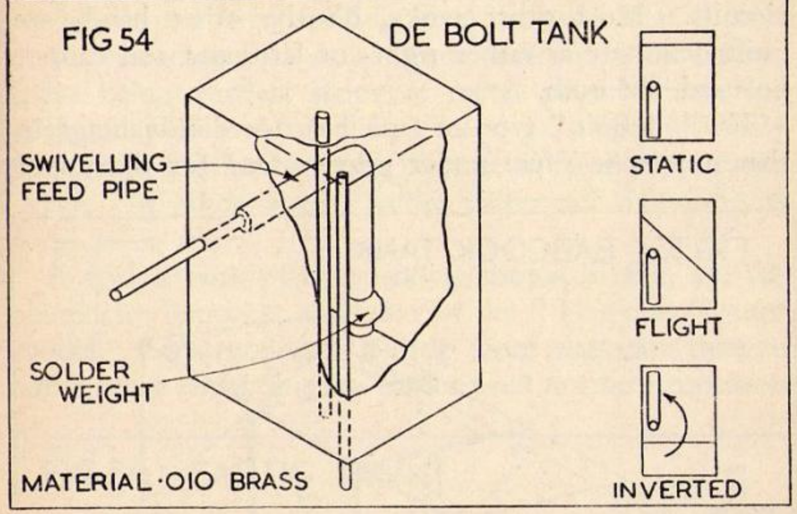
This is the principle of the " EmDee Eezi-Flo " fuel tank shown in Fig. 53. To compensate for the difference in suction lift in level and inverted flight the fuel pipe is located on approximately the same level as the needle valve so that the suction lift is zero in both attitudes. In practice this works extremely well. The

FIG 53 EMDEE TANK



MATERIAL BRASS NICKEL PLATED

FIG 54 DE BOLT TANK



MATERIAL ·010 BRASS

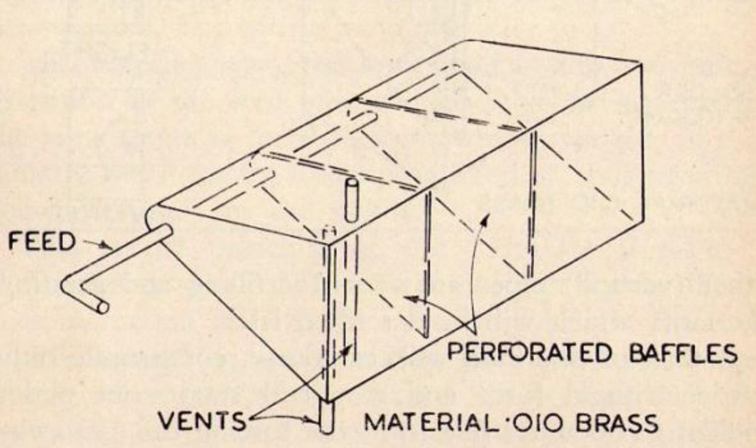
other (vertical) pipes are vents for filling and aerating the tank, which will be described later.

A tank of this kind will, of course, compensate only for centrifugal force and may still starve out under violent manoeuvres due to inertia forcing the fuel away from the end of the tank. This, however, very seldom occurs, but any possibility of it happening would be minimised by decreasing the *length* of the tank. In other words a short tank would give the fuel less chance to surge backwards and forwards.

The original " deBolt " stunt tank is deep and short, with the same sort of swivelling feed pipe, Fig. 54. but in this case the feed pipe is located on the outboard side of the tank. It will be noticed that it is still not a " handed " tank. That is, it can still be used for both clockwise and anti-clockwise circuits simply by inverting the tank so that the feed pipe comes to the outboard side of the circuit. The " EmDee " tank being symmetrical, can be used also for both clockwise and anti-clockwise circuits. Most other tanks, on the other hand, are built definitely as either right- or left-hand and cannot be used for both.

The " deBolt " type of tank has one disadvantage in that it supplies fuel under gravity feed for the upper

FIG 55 BABCOCK TANK



half of the tank when the motor is operating, i.e., once the fuel line is full the high fuel level in the tank produces a syphon effect. However, with the needle valve adjusted to this condition, trouble is seldom experienced in practice, although the feed does eventually change over to suction feed as the tank empties down.

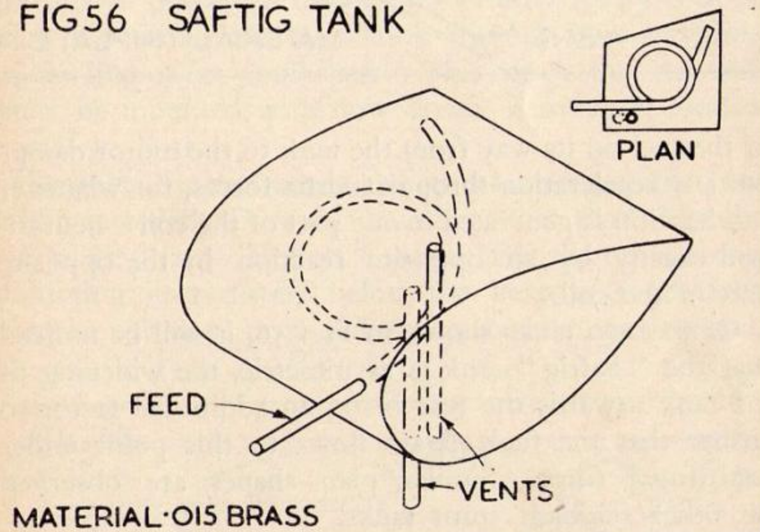
Most small tanks are reasonably free from troubles due to fuel surge, but in some of the larger sizes this may be appreciable. For example, a sudden pull up when the tank is partially empty may tend to throw the fuel forwards (since the model slows up) and temporarily starve out the motor, just at a time when ample power is needed. This is particularly true of some of the larger

wedge-shaped tanks feeding from the outer rear corner.

To eliminate fuel surge some tanks employ baffles, these being vertical strips of metal placed across the tank and perforated to allow fuel to pass through freely enough to maintain supply, but not so freely as to cause surge. In other words, baffles damp out the surge as soon as it starts.

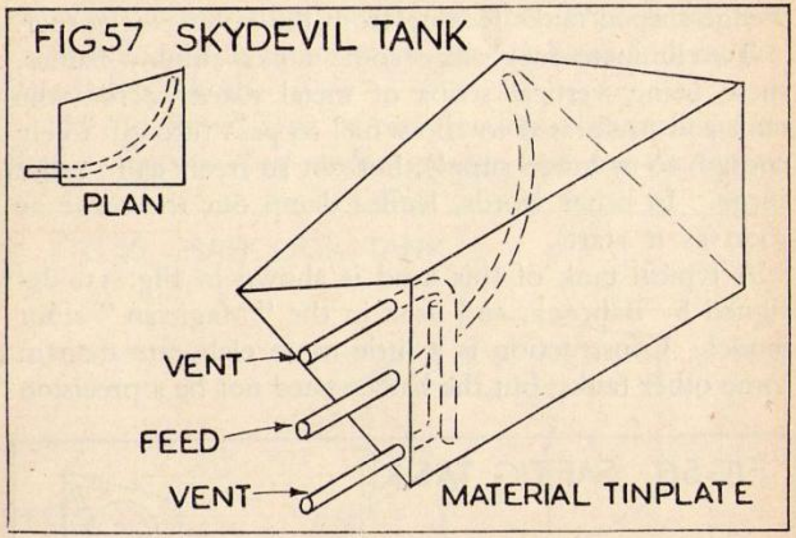
A typical tank of this kind is shown in Fig. 55, designed by Babcock, and used in the " Magician " stunt model. Construction is a little more elaborate than in some other tanks, but the baffles need not be a precision

FIG56 SAFTIG TANK



fit in the tank, it is sufficient to ensure that they do remain there.

A simpler method which has been used successfully on conventional wedge-type tanks is shown in Fig. 56, where the feed pipe is coiled round inside the tank before emerging from the front. This 360 deg. circuit



of the fuel on its way from the tank to the motor damps out any acceleration through inertia forces, for whatever acceleration is generated in one part of the coil is neutralised exactly by an opposite reaction in the opposite part of the coil.

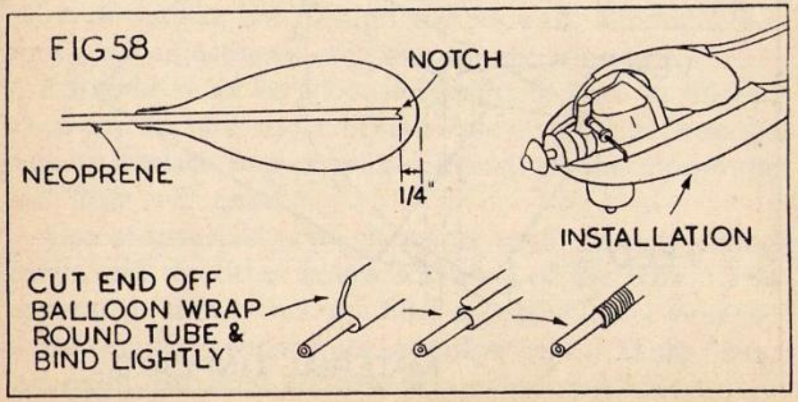
Of the two tanks shown in Fig. 56, it will be noticed that the " Saftig " tank is asymmetric, the widening of the tank towards the rear being an additional factor to ensure that the fuel always flows to this point under centrifugal force. Similar plan shapes are observed on other standard stunt tanks.

The " Bat " tank and the " Sky Devil " tank, Fig. 57, are triangular wedge tanks which are considerably easier to duplicate in the home workshop than the rounded wedge type. Their efficiency is quite as good, for the same basic principles are observed. The one practical disadvantage of all wedge tanks with wide rear ends is that they are often too bulky to accommodate in the

fuselage at exactly the right level. Usually some little experimentation is necessary to find the optimum position for a stunt tank and if the tank is wider than the distance between the bearers, or even the fuselage itself, it is not always easy to find a suitable attachment position.

Experience has shown that it is best to mount the tank as close to the motor as possible, with the feed pipe roughly on the same level as the needle valve. With the normal side-port motors this generally gives a tank position above the motor bearers and it is usually quite easy to locate this accessory either to the bearers themselves or to a suitable part of the fuselage sides. But most powerful motors now have rotary valves, with the needle valve position roughly corresponding to the line of the crankshaft. This means that the tank must be mounted quite low down, between or underneath the bearers.

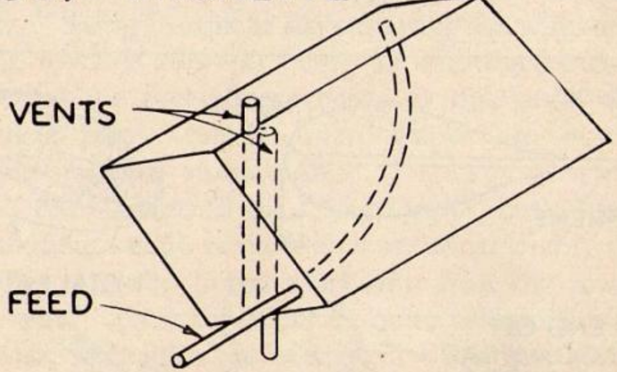
Between the bearers is the worst position, for here width is strictly limited. It is here that tanks like the " EmDee " and " DeBolt " score. For the other tanks, mounting immediately below the bearers is generally the best solution, provided the lines of the tank can still



be accommodated within the outline of the fuselage. In extreme cases the tank is left projecting, for it is better to have a power unit which really works efficiently than one which looks clean but will not function properly at all flight attitudes.

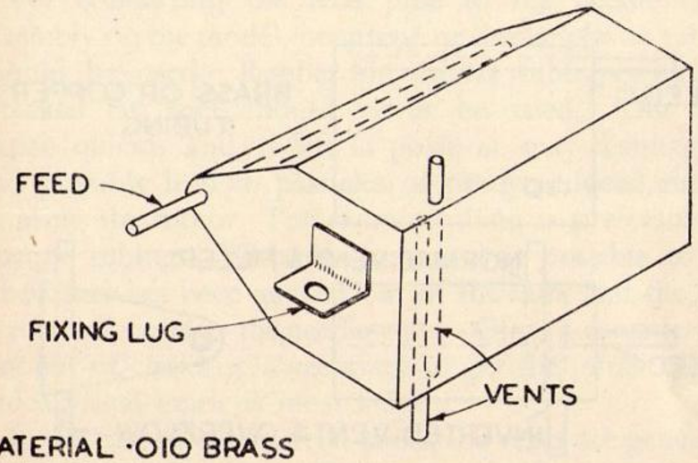
Since fuselage proportions vary considerably with different free lance designs it is not uncommon to find stunt tanks "tailor-made" to fit a particular model, these tanks being designed on the above principles. The "Dronette" design has already been mentioned and has a diamond shaped fuselage. To fit this shape the fuel tank is also diamond shaped, see Fig. 59, with the feed pipe arranged to feed from the outer end of one horizontal diagonal. In such cases the height of the tank preferably should be less than the depth to reduce the slope of the lower faces; centrifugal force will then throw the fuel up this face quite satisfactorily and almost empty the tank on each run. It is not absolutely necessary that the tank should feed fuel right down to the last drop.

FIG 59 DRONETTE



MATERIAL TINPLATE

FIG 60 JONSONBILT TANK

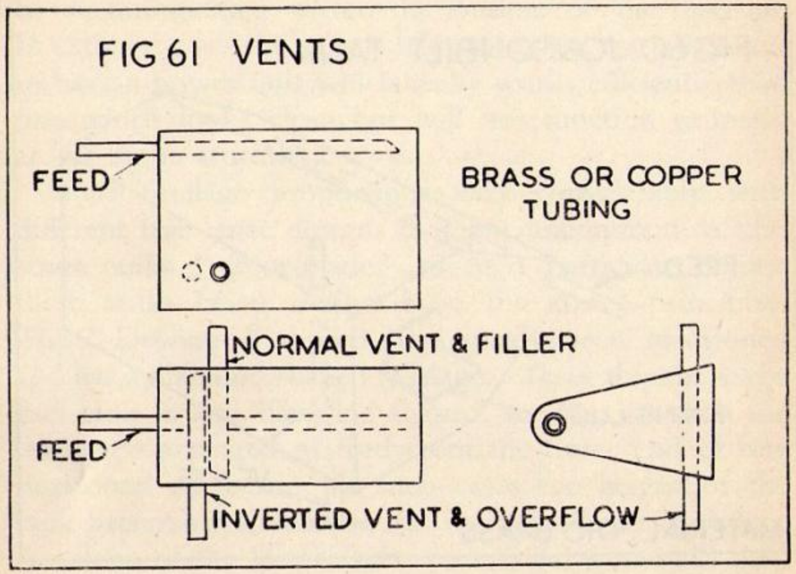


MATERIAL ·010 BRASS

The most convenient way of fixing a tank to the airframe is to solder tinplate or brass lugs to the outside, these being drilled, see Fig. 60. The tank can then be screwed directly on to the bearers or other suitable part of the fuselage structure. In other cases the tank may actually be built into the fuselage structure, housed in a balsa or similar box behind the firewall, although this allows no adjustment of position once installed.

All tanks must be adequately vented, both to fill and to enable the tank to feed fuel. Unless air can get into the tank to replace fuel as it is delivered to the motor the fuel flow will cease.

Almost invariably two vents are used, one projecting above and the other below the level of the tank. The uppermost vent is then the filler pipe, the lower vent the actual aerating vent and also overflow pipe. Tanks being invariably of metal construction it is impossible to see



when they are full, the only indication being an overflow of fuel through the bottom vent pipe.

A typical venting system is shown in Fig. 61. Both vents are located on the inboard side of the tank and extend the full depth of the tank. Fuel cannot siphon or leak out with the tank full. Vents, too, should be of adequate diameter and always kept clear. It is normally impossible to fill a stunt tank should the overflow vent be blocked for air cannot escape from the tank unless the needle valve is opened (when it escapes via the feed pipe) A minimum of 14 s.w.g. (internal) tubing is recommended for vent pipes and the same for feed pipes.

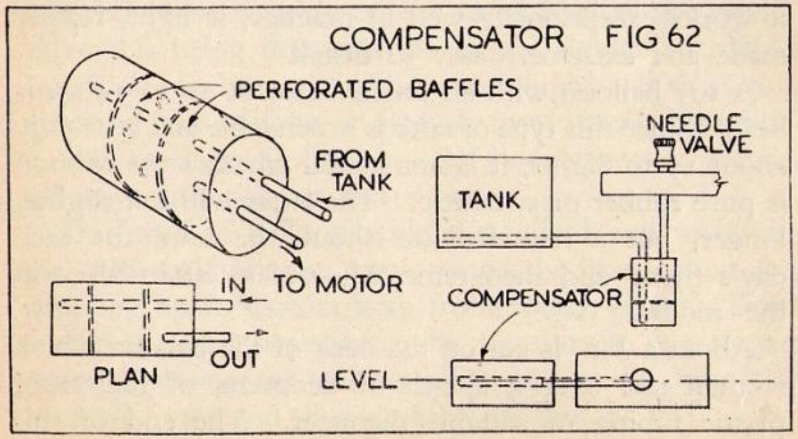
Large motors, and particularly those operating on glow-plug ignition, have a relatively heavy fuel consumption. Generally, the makers in such cases specify a minimum diameter for the fuel line: 14 s.w.g. tubing is quite adequate for motors up to the "Ohlsson '60'"

but the more powerful motors in this class require thicker piping.

For connecting the feed pipe to the needle valve assembly on the model, neoprene or similar plastic tubing should be used. Rubber or similar tubing which is attacked by fuel should never be used. This will perish quickly and, if left in position, may disintegrate and possibly lead to particles of partly reduced rubber entering the motor. Transparent tubing is preferable to opaque tubing. With the former it is possible to see when fuel has been sucked out of the tank and the fuel line is full right to the needle valve. Often a considerable amount of choking is necessary to get the initial supply and a visual guide is most helpful.

In the case of commercial tanks, the vents are generally quite short. For practical reasons, both vents should project from the fuselage and so before finally installing in the fuselage a short length of plastic tube should be slipped over each vent pipe to provide the necessary extension.

Transparent tubing will also show up bubbling or undue aeration of the fuel as it approaches the needle



valve. Very often unsatisfactory motor performance can be traced to undue aeration of the fuel between the tank and the motor. To the eye, the fuel does not flow in a constant stream through the fuel line, but is mixed with numerous air bubbles at frequent intervals and the motor runs rough or even starves out.

One of the chief causes of this is excess vibration aerating the fuel in the tank itself, or the fact that the fuel tank is nearly empty. A symmetrical wedge tank, for example, will have to be more than half full to start satisfactorily when the model is static, although it may feed down to the last drop in flight.

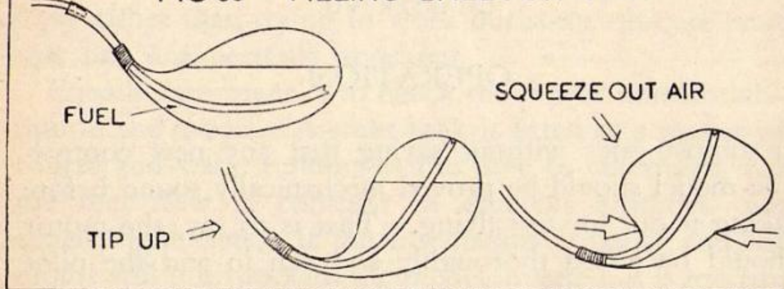
Sometimes a device known as a compensator is used between the tank and the motor to smooth out the fuel flow. In many cases these have proved the answer to apparently insoluble difficulties, but most normal systems will operate satisfactorily without recourse to such accessories. A typical compensator is shown in Fig. 62.

From the point of view of sheer simplicity, the balloon tank, introduced by Jim Walker, has no equal for stunt work, Fig. 63. In spite of its apparent crudeness it works exceptionally well in practice, is light, readily made and extremely easy to install

A toy balloon with an inflated size of 10 to 14 in. is best. Since this type of tank is expendable and lasts only about 15-20 flights, it is immaterial whether the balloon is pure rubber or synthetic. The latter will last slightly longer, but a new balloon should be used for each day's flying and then removed—never left in place in the model.

About a ¼ in. is cut off the neck of the balloon which is then slid over a length of neoprene of fuel-proof plastic tubing of suitable diameter. The end of this

FIG 63 FILLING BALLOON TANK



tubing should be V-notched, as shown. Then simply wrap the end of the balloon with thread to make a fuel proof joint with the tubing, taking care not to pull this binding too tight and thus restrict the flow of fuel.

To fill the tank, a pressure fuel can is best. The tank is removed from the motor and connected directly to the nozzle of the pump. Pump fuel in until the balloon is somewhat over half full and then squeeze out surplus air.

To connect the tank to the motor, simple slip the free end of the neoprene tubing over the needle valve assembly. The tank itself just rests in the fuselage and should be roughly on the same level as the needle valve this being important to ensure similar fuel flow conditions in normal and inverted flight. It does not matter if the balloon is free to move around slightly in the fuselage as long as this movement is mainly sideways and not up and down.

This type of balloon tank is standard equipment in the "Fireball" stunt version and is best suited for coupling up to motors with front rotary valves. Used with rear port motors it may be necessary to fit a simple guard to prevent the balloon falling against the end of the air intake tube and thus choking the motor.

CHAPTER VII

OPERATION

It almost goes without saying that any new control-line model should be proved mechanically sound before taking it out for test flying. That is to say, the motor should be tested thoroughly and run in and the pilot thoroughly familiar with starting and adjusting it and a " standard " fuel adopted. Preferably use the most economical fuel which gives satisfactory running. Bench testing provides an ideal opportunity of getting to know a new motor and also trying out different fuels to find the type most satisfactory and non-sensitive for that particular power unit.

Remember, too, particularly with glow-plug motors, that weather conditions may often affect the running of a motor. Different proportions of nitrated dope are often necessary under different temperature and relative humidity conditions. This factor becomes even more important in the case of speed models, where absolutely maximum power is desirable. Stunt models are not so exacting in this respect. Maximum power is required, but more than absolute peak performance, *reliability* is the chief requirement.

Since every motor has slightly different characteristics it is most important that every flier " gets to know his motor." This may save a lot of useless prop turning without results on the flying field. Starting difficulties and other little idiosyncrasies of a motor are best worked out at home. Every modeller has his " off " days, but normally when a model is taken out to the flying field—even for its first test flights—it should be possible to

start the motor in a matter of seconds and spend the time *flying* rather than trying to work out some obscure fault that has unexpectedly appeared.

Equally important is to check the power unit installation in the model. A stunt tank is fitted as a matter of course and static running is the time to determine that the fuel flow is constant in different attitudes—not actual flight tests. If the installation is faulty and the motor will not run with the model inverted, it is too bad if this shows up on a test flight, for then the only action possible is to land the model in the inverted position and hope that any damage resulting will be slight.

To test the tank system, start up the motor normally (then switch over to flight batteries, or disconnect the glow-plug, where applicable), and then suddenly invert the model. The motor should continue to run smoothly, with no hesitation or change in mixture setting. Try the model in various other attitudes, corresponding to every portion of a loop, doing this slowly to check that the motor will continue running in any position.

Under static conditions the tank should be full to the brim for such tests. As we have seen, most stunt tanks are designed to utilise centrifugal force to maintain fuel feed, over the latter part of the tank capacity at least. Conducting static tests with a half empty tank may give most misleading results.

Some modellers even shake the model during such static tests—mainly with the idea of producing fuel surge and seeing its effect on the motor running. However, this is probably more drastic than any forces likely to be set up under actual flight conditions and a motor which cuts out when the model is shaken thus may still perform quite satisfactorily in flight through the whole aerobatic range. If the motor *does* run satisfactorily when the model is shaken it will almost certainly function well in flight.

Two other static checks are also very useful.

The one which applies to all types of motors is to check the actual length of the motor run from a full tank and to simulate flight conditions it is recommended that the model is held on its side (outboard wing downwards) once the motor has been adjusted for smooth running. This will ensure the tank emptying properly. This, of course, is not necessary with tanks like the " EmDee " and the " deBolt."

Under actual flying conditions the duration of the power run will be somewhat less, since the motor will speed up in the air. Actual flight duration is roughly 10 per cent. less than static duration.

The most economical motors are spark-ignition types running on petrol-oil mixtures. The " Ohlsson ' 60 '," for example, will run for approximately 4½ min. on 1 oz. of petrol-oil fuel, and nearly 3½ min. on the same amount of methanol fuel (still spark-ignition). Fuel consumption on most glow-plug motors is extremely high—at least twice that of petrol-oil—whilst diesels generally come between the two.

Ideally the static power run on a stunt model should be about 5 min. This gives about 4½ min. power flying, which is a nice comfortable time to complete the necessary flight pattern. For competition work, 10 min. is usually allowed for the completion of a selected flight pattern, irrespective of the number of flights. A five-minute tank allows one flight to be completed comfortably within the time limit and leave ample time for another attempt should this be necessary to carry out some further manoeuvres.

A full 10 min. tank may seem desirable, so that every manoeuvre can be attempted in one flight with time to spare. But there is one serious disadvantage to this. As frequently happens a motor may begin to run rough after a little flying and the power drop right off so that further stunting is impossible. If the pilot then has simply to fly out his full time like this, it is just too bad. But if he knows his fuel will run out well within the limit and allow another flight with a readjusted motor, then his competition chances are much brighter.

Motors suddenly developing " temperament " can happen with the best of models and fliers. It is just one of those unfortunate chances which must be faced in competition work.

Some fliers have regarded this feature so seriously as to consider the fitting of some form of cut-out so that the motor can be stopped at once if it starts running badly and the model landed and another flight made straight away. The two conventional forms of cutting out a motor—the third line or electric impulse through the control lines themselves have been described in Book I. The latter is definitely preferable.

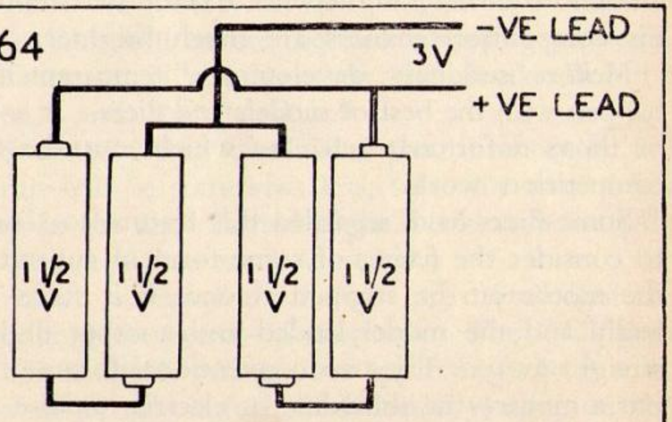
Stunt flying has now reached the standard where something exceptional is needed to stay at the top of the contest field and two-speed motor control is being considered very seriously for competition work. Hitherto its use has been confined mainly to sports flying or American contest work.

With all spark-ignition motors, static runs should also be made on the flight batteries to check the useful life of these batteries. About the minimum useful size for a flight battery for control-line work is four pencells grouped in two batches of two each, i.e. a series connection of two paralleled pencells, Fig. 64, giving

3 volts and roughly 4 amps. A battery of this type should have a useful life of some half a dozen five minute flights.

An equivalent ready-made battery is the 730 or 731 size, comprising two larger cells in series, again giving 3 volts and an amperage of approximately 5. These have a slightly longer life, provided they are fresh and in good condition when purchased.

FIG 64



SOLDER ALL CONNECTIONS

Since so much depends upon the efficiency of the flight batteries, these should be selected carefully. Some makes are very much better than others for model ignition work, being capable of giving the relatively high amperage required readily without polarisation. It must be remembered that these cells are, originally, designed for quite a different purpose—lighting a flashlight bulb in a torch where the current consumption is minute by comparison. Hence, slight differences in manufacture make one brand better than another for flight batteries.

A small ammeter is a very useful instrument to have in checking new flight batteries. This could be used to check cells before purchase or test cells which have had some use and are now classed as "doubtful." A fresh pencell in good condition should give a reading of at least 4 amps. Anything less than 3 amps is relatively useless for model ignition work. This will, of course, depend to a large extent on the coil used. Some coils are particularly good in operating at low amperages, whilst others are particularly greedy in this respect. But by setting the standard given above any normal model coil will function satisfactorily.

One word of warning in using an ammeter to test dry cells. The resistance of an ammeter is very small and when connected across a cell is virtually short-circuiting it. Therefore only hold the leads on the cell as long as is necessary to obtain a reading.

For booster batteries, nothing is better than lead-acid type accumulators of reasonable capacity. Although somewhat bulky and apt to be messy, their advantages in providing a good hot spark for starting under almost any conditions make them the logical choice.

With normal use they require little re-charging and one charge alone will generally outlast several bell-type dry batteries.

For glow-plug operation an accumulator type booster battery is almost essential. Glow-plugs take on an average as much as 7 amps, which will flatten even a large dry battery in a minute or so. An accumulator on the other hand, will take considerable abuse and still give ample current for starting.

Maximum voltage for glow-plugs is 2. All of the glow-plugs of British manufacture will take the full 2-volt discharge without burning out, although most

American types burn out quickly at this figure. The Americans do, in fact, specify $1\frac{1}{2}$ volts as the maximum to be used. $1\frac{1}{2}$ volts is, in any case, sufficient for any glow-plug and to step down an accumulator to this figure a .1 ohm resistance should be incorporated in one of the leads. It is sometimes not appreciated that a glow-plug can be too hot for easy starting. A dull red glow generally gives easier starting than a pale yellow glow, and in any case the lower voltage used will prolong the life of the plug. A high voltage connection will considerably shorten its life if left connected for any appreciable time once the motor is running.

By comparison with the above, diesels are simplicity itself. But although the details of spark- and glow-plug ignition batteries have been described in some detail, provided these features are properly attended to, both the latter are quite satisfactory.

All the necessary equipment for flying—batteries, fuel and spare propellers, prop spanners, plug spanners and a screwdriver, should be kept in one convenient box, preferably fitted with a handle for ease of transport. Everything necessary is then to hand. Fuel is best made up before starting out for a day's flying. Make up ample for all requirements and use a small fuel can for actually filling the tank. Filling a stunt tank is not always as straightforward as might appear, and by far the best type of filler is the type of oil can fitted with a piston or plunger which actually pumps fuel out of the nozzle. This pressure feed is far more reliable, and much quicker, than " gravity feed " from a conventional fuel can. Remember, too, that since the fuel tank is not transparent (and often completely hidden in the model) to keep on filling until fuel flowing out of the bottom vent indicates that the tank is full.

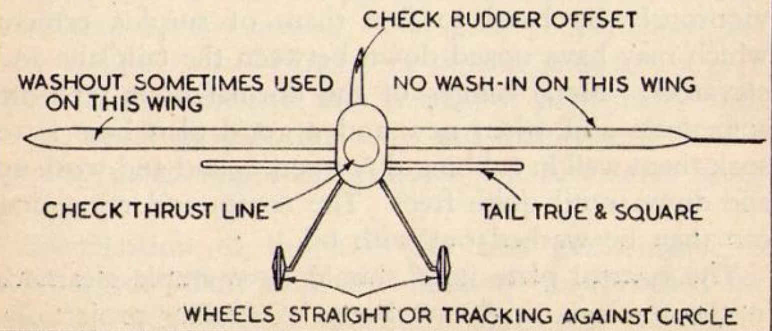
With proper venting it is always advisable to close the needle valve completely when filling. In most stunt tanks there is very little difference in position as regards gravity feed and fuel may easily flow through the feed pipe past the needle valve (if open) and flood the motor. Where the metal vent pipe itself projects from the model a short length of plastic fuel tubing on the end of the fuel can makes an ideal connection. If the projecting tube is itself plastic, the fuel can can be connected to this.

When starting, choke the motor and turn the propeller over until the fuel line is full and fuel appears at the needle valve. Then choke again lightly as necessary to start. Models should always be designed so that it is readily possible to get at the intake tube with the fingers to choke instead of relying on some mechanical device to do this. That is one of the advantages of the crankshaft rotary valve motor, where the intake tube is invariably in front of the cylinder.

An alternative method of filling the feed pipe before starting is to blow through one of the tank vents, forcing air into the tank and thus fuel into the pipe line.

As a final check before flying, inspect the model for

FIG 65



warps, balance, and freedom of control movement. Normally the wings should be quite free of warps. Some designers introduce washout on the outboard wing, or wash-in on the inboard wing to help in maintaining line tension but this is unnecessary and bad practice. It is better to line up a model dead true, Fig. 65.

If the tailplane is of sheet construction it is extremely unlikely that this will ever get warped, and so the main check here is to see that the tail is lined up correctly with the wings. A tail set at an angle to the wings will tend to make the model bank and turn, so again a true line-up should be used.

Free movement of the control system is essential for best performance. In some manoeuvres on long lines the lines themselves are very slack and if the controls are stiff or binding, movement of the control handle will produce little or no corresponding elevator response. But with the controls nice and free full control can be maintained even with slack lines.

The chief source of stiffness is usually the hinges. Metal hinges are best, for they can be made to operate very smoothly, but will only do so if lined up correctly. A spot of thin oil on metal hinges will also help. Fabric hinges are inherently stiff and should be worked quite vigorously by hand to free them of surplus cement which may have oozed down between the tailplane and elevators. Metal hinges of the normal door type are sometimes stiff when new and a good plan here is to soak them well in rubbing down compound and work up and down until quite free. The compound remaining can then be washed out with oil.

The control plate itself should have ample clearance in the fuselage, with no chance of fouling projections

or part of the structure over the whole of its travel. Similarly the lead wires should fit smoothly in the guides. Sometimes the lead wires have a tendency to snag part of the structure where they are made off on the control plate, so check this carefully and modify the attachment to cut suitable clearance as necessary. A spot of oil on all pivot points will also help.

Finally check the centre of gravity position with the tank empty and see that it comes within the rearward limit specified. If the model seems excessively nose-heavy, check again with the tank full and see if the centre of gravity is still within the wing chord. Provided it is still some distance behind the leading edge the model should perform quite satisfactorily. A forward c. of g. position is quite safe, but usually makes the model trim nose-heavy which is not particularly nice for stunt work.

Errors of c. of g. position are best corrected by shifting some heavy component, such as the flight batteries or coil, or even re-positioning the motor in its bearers. Adding ballast weight is not good practice on stunt models, although this may have to be done as a last resource. But if the design proportions given in an earlier chapter are followed, it is very unlikely that the final c. of g. will come outside the optimum limits.

Lines are the next important consideration before test flying can commence. Too many people regard the lines as just a small part of the scheme and do not give them all the attention they need, but particularly with large, heavy models, line care and maintenance is one of the most important features of successful stunt flying.

Specification of the lines for best performance is fairly rigid. Only thin steel lines are really suited for stunt work, having minimum drag and maximum strength. Flax or linen lines should be rejected as having too much drag. Likewise thick, stranded lines are quite unnecessary on even the largest stunt models and again have excessive drag.

A line diameter of 0.008 in. (36 s.w.g.) is generally satisfactory for all small and medium sized models. Many people fly even the largest models on lines of this size, although it is more usual for anything over about 30 oz. total weight to fly on 0.010 in. diameter lines. Best quality spring steel or piano wire should be used, preferably nickel plated or similarly treated to resist corrosion. Once a rust spot appears on a line its strength is seriously impaired and it should be rejected.

The chief line fault is kinks, which may develop through careless handling in reeling the lines in or out, or from people stepping on the lines when they are laid out on the ground prior to or between flights. Once lines have been badly kinked, even once, they should be rejected and another set used.

Kinks or other similar deformation of the lines not only weakens them but may also cause snagging. A snag is the result of the two lines coming together and wrapping themselves round one another, often locking the controls completely. Thus with badly snagged lines the pilot has no further control over the model. Should this occur, the result is usually a crash and about the only action possible to attempt to unsnag the line is to step forward smartly to slacken the lines right off and then jerk them taut, hoping they will free. If the model is flying level when the lines snag it is best just to hang on until the motor cuts.

Excess vibration is another cause of snagging lines, the vibration of the model being transmitted to the lines which themselves vibrate and wind round one another.

Snagging is most common with kinked lines, or lines which have been in use for some time. Dirty, uncared for lines are more likely to bind than fresh, straight lines, hence, it is good policy with stunt models to use one set of lines for a limited period only, say, one or two week's flying, and then scrap them and make up a new set.

Actual line length for stunt work is best adjusted to the size and power of any particular model. About the minimum length of line for satisfactory stunting is 40 ft., and frequently contest rules quote this as a minimum figure for all models, irrespective of size. The upper limit is generally 70 ft., although line lengths of up to 100 ft. have been used.

In general, the faster and more powerful the model, the longer the lines on which it should be flown. Speed relative to the pilot can be controlled by adjusting line length. But the actual factor limiting line length for stunt work is the flying characteristic of the model itself. Whilst a particular model may be quite safe on lines of, say, 70 ft. in length, it may have a marked tendency to slacken off the lines on top of a loop, or during a wing-over. Hence, for full stunt work a slightly shorter length would be preferable, 60 to 65 ft. being a good average figure.

For loops and similar manoeuvres, the longer the lines the better—provided they stay tight all the time. Vertical wing-overs are easiest on short lines, but looping on short lines may be dangerous unless the model has a very small looping radius. On short lines, too, a bunt may be quite risky.

About the best practical way to determine line length is to use the maximum length of line on which the model will do a perfectly vertical wing-over without the lines slackening off. As a further guide, the following are very general figures for the three main classes of stunt models :

TABLE VI

Size of model	*Line diameter*	*Maximum line length*
Small, around 150 sq. in.	0.008	40 ft. lines as a minimum, but seldom longer.
Medium, 200-250 sq. in.	0.008	50 to 55 ft.
Large, 250-350 sq. in.	0.008	55 to 65 ft.
Very large, 350-500 sq. in.	0.010	65 to 75 ft.

If the model will not fly comfortably on the line length specified ,e.g., has a tendency to come in on the pilot in high altitude flight, then possibly the model itself is at fault. The most common fault is lack of power. Other contributing factors are bad rigging, see Book I for factors affecting line stability. General data on line maintenance, storage, making off ends, etc., are also given in Book I.

Initial test flights are often carried out on slightly shorter lines to get the feel of the model before attempting any advanced manoeuvres on longer lengths. Line stability can simply be tested by a series of wing-overs, approaching more and more to the vertical each time. If there is no tendency to slacken off the lines on the top of a wingover, then the model will almost certainly loop successfully, provided the correct amount of elevator movement is available.

Test flying is merely a confirmation that the basic layout is sound, both mechanically and aerodynamically. Faults may show up in the former with regard to the fuel supply, the motor tending to cut out as the model picks up speed or is put through a mild manoeuvre, such as a steep climb. Such faults as these must be attended to

by adjusting the fuel tank position or even fitting another tank of different form in bad cases.

Line stability can be improved, if necessary, by suitable adjustment and also the motor-propeller combination checked. If the motor appears to be giving ample power, but thrust is rather low, a change of propeller is indicated. Usually a higher pitch propeller will produce better results. When the pitch of the propeller is too high the take off is unduly protracted and the model may never pick up maximum flying speed, even when airborne. With the propeller of too fine a pitch the motor will appear to rev. excessively without producing sufficient thrust. Using too fine a pitch is a more common fault than using a propeller with too much pitch. Test flying with different propellers is the only way to determine the best size to use for any particular model and motor.

There is no need to prolong the test flying period unduly. In fact the sooner a new model is used for aerobatics the better. Practice in actual stunt flying is far more valuable than continued straight and level flying if the machine *is* intended for stunt work. Motors are an expensive item and they do wear out—so make full use of their working life.

As regards the wear and tear on motors, conditions in control-line flying are quite exacting. The motor is run continuously at full throttle for periods of up to five minutes at a time. Some quite powerful motors wear out surprisingly quickly under such conditions, but most will last at least one season with reasonable care (excluding damage that might result from crashes). Diesels are generally particularly good in this respect, having a useful working life at full throttle running of well over 100 hours. And 100 hours' actual flying time is a long period !

The useful life of a motor can be greatly reduced by lack of care and attention. Dust, in particular, is harmful and most flying fields are dusty during the summer months. Particles of this dust adhere to oily surfaces, such as the outside of the motor, and may also reach the inside via the exhaust port. It is a very good plan to have covers to fit over the exhaust and intake of the motor when not in use. Most of the wear on motors does, in fact, come from dust and dirt which gets inside the motor and increases wear on the piston and cylinder.

Dirty fuel is another source of excessive wear, and also fuel with incorrect lubricant. Methanol fuels are best for cool running and the castor oil lubricant used with such fuels has no equal. But normal petrol-oil mixtures are quite satisfactory, provided oil of at least SAE 60 equivalent is used (see Book 1). Poor lubrication will cause overheating and excessive wear and so most modellers use relatively oily mixtures with spark-ignition motors, a proportion of 3 : 1 petrol : oil very rarely being exceeded.

Finally, proficient stunt flying demands constant practice; and suitable flying fields are not so easy to find. Although control-liners can be flown from quite restricted spaces, the noise (or danger) element has resulted in their being banned in many public parks. For test flying in urban areas, i.e. where there are houses in the vicinity, a silencer can be a good investment, eliminating one possible source of complaint—noise—at the source. Of the few commercial silencers developed to date, all are satisfactory from the point of view that they do cut down the noise of the motor to a reasonable degree without detracting from performance. Some silencers do, in fact, actually increase the performance.

This question of silencing is more important on the

larger motors which are inherently noisy. Most of the small diesels are inoffensive in this respect. However much the modeller may dislike the idea of silencing his model—for much of the thrill of flying a big stunt job is the noise it makes—it is far better to fit a silencer and be able to fly at all locally than it is to fly once or twice with the motor roaring away at its top note and then get control-line flying banned for the future in that particular area.

To conclude this chapter some notes on airframe repairs are appended. Stunt models do crash, all too frequently, in fact—and almost always the fault lies with the pilot. But that in itself is no consolation. The problem is, whether or not it is worth repairing a model which appears to have smashed itself to pieces.

Experience has shown that very rarely does a model damage itself beyond repair in one crash—however serious the damage might appear. Models where the wings have been broken in two or more places, with the fuselage in half and the motor mounts knocked clean out of the structure have been rebuilt in a matter of a few hours and flown successfully again. Instead of regarding the job as hopeless from the start, an approach from the angle of seeing what can be done will often convince the modeller that it is worth repairing a seemingly hopeless mass of wreckage. It may never be a top line contest machine again, but it can be a useful reserve and a model for practice. The point is that in at least seven cases out of ten it is much quicker to repair a broken model than it is to build a replacement.

CHAPTER VIII

STUNT SCHEDULES

A GOOD stunt model is capable of a very wide range of manoeuvres. Apart from the obvious or "standard" manoeuvres, such as loops, inverted flight, wing-overs and so on, variations of these basic stunts can be worked in as the skill of the pilot improves.

For contest work it is very necessary to introduce a fixed schedule of manoeuvres, with points allotted to each, and entrants allowed to attempt any or all of these specified stunts. They are required to present the judges with a flight pattern before making their attempt, which details the individual stunts they are going to attempt and in the exact order they intend to fly them off. If this were not done, the judges' task would be hopeless indeed.

Quite apart from the stunt schedule being the basis of all competition work, it is also a very useful guide to the sporting flier who, whilst never possibly having any ambitions as regards entering a contest, does wish to improve his own standard of flying. The schedule then lists what can be done, or what the real experts *can* do.

In working out a flight pattern it is as well to bear in mind that loops and similar manoeuvres will give a complete twist to the lines (once around each other for each loop). This will have little or no effect on the controls provided the lines are in good condition and, in fact, as many as fifteen loops can be carried out in one flight before any appreciable stiffening up of the controls is felt. But from the point of view of safety, five twists

are really enough—so plan out a flight pattern which follows loops with bunts or some similar manoeuvre which will unwind the lines once more. Never go from consecutive loops to other manoeuvres which add still more twists without interposing some manoeuvre to unwind the lin esfirst. At the end of each flight, of course, the lines should be sorted out free of twists before taking off again.

The first stunt schedule listed in this country was prepared at a time when no one had advanced beyond looping a model. It was, therefore, based mainly on American practice and was prepared by a special sub-committee of control-line fliers, of whom the writer was one, with a view to covering all possible flight manoeuvres, and it was anticipated that it would take at least two years, and possibly more to work up to the full standard required. That is, it was not expected that anyone would gain maximum points on this schedule for some considerable time and that the original list would therefore stand as a basis for the next few years.

Unfortunately, certain shortcomings were shown up during the 1948 flying season, one of the most important being the fact that certain of the manoeuvres were definitely over-rated. That is, too many points were given for consecutive loops, for example, as compared with certain other stunts.

Also the very wide range of stunts listed was, in effect, duplication, although with the model in the inverted position, and the fact that so many different manoeuvres were possible on the original schedule did make judging such an event a severe task for the panel of judges. This was exaggerated by the fact that, for true scoring, it is essential to keep the same judges throughout. The same judges see and mark each competition flight which, with upwards of twenty entrants, is no mean task.

The original schedule also left one big loophole in the rules as regards inverted flying. It was quite in order for any pilot to invert the control handle when he inverted the model, so that inverted flying became simply a matter of flying round the circuit in the opposite direction, still with " normal " controls. Manoeuvres from the inverted position thus implied no additional skill, other than inverting the handle when taking the model over on to its back.

Inverting the handle presents no special difficulties. There are two simple ways of doing this. One method is to twist the wrist so that the " up " line comes at the bottom. This is possibly the simplest way, but leaves the pilot in a rather awkward position for subsequent control action. However, with practice this trick is readily mastered. The other, and probably the best, method is to change the control handle from one hand to the other, inverting the handle as you do so. This leaves the control handle in the left hand for inverted flying, when it can be switched again to the right hand (still in the inverted position) if desired. This gives full freedom of the wrist for control movement, the main disadvantage being the time lag during the change-over. Should it be necessary to recover to normal flight quickly control may be lost in a frantic switching of the handle again.

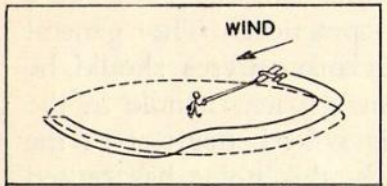
A further method is to use a control handle which automatically inverts itself when tripped, so that normal control is retained without either twisting the wrist through 180 deg., or switching hands. Details of such a control handle have been given in Book I.

These methods of dealing with inverted flight manoeuvres received severe criticism during the 1948

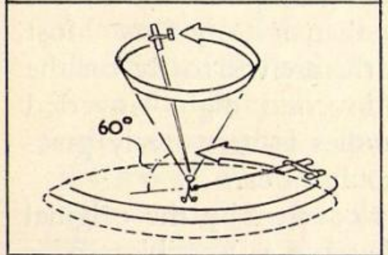
competition season and in some contests rules were introduced prohibiting such practice. The general reaction is that inverted flight manoeuvres should be carried out with reversed controls, i.e., handle in the " upright " position, as this is a far better test of the pilot's skill. Strangely enough, this point has caused more concern in this country than in America. Most American stunt pilots taught themselves to fly on the straightforward principle of inverted flight—inverted controls and inverting the handles is very rarely practised. However, new rules prohibit this.

One other major point not covered by the original stunt schedule was the fact that it was possible, under the rules, for a model to crash several times and, provided suitable repairs could be carried out within the 10-min. period allotted, the entrant was not penalised as regards points scoring. This was particularly emphasised by the small stunt models, which could often crash with little or no damage, usually a broken propeller being the result and, with little or no repair work go on to complete the flight pattern. As a temporary measure, local rules were introduced in later contests whereby points were lost for damage to the model during the course of its competition attempts—damage being generally defined as a broken propeller. The new stunt schedule, incidentally, still leaves this question open for local ruling.

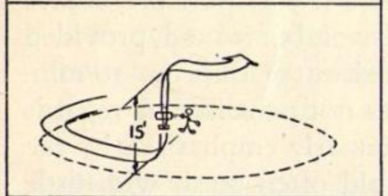
In spite of its limitations in many directions, the original stunt schedule still provides an excellent flight pattern for training work, covering, as it does, most of the possible manoeuvres. As such, therefore, it is listed and, for easy reference, it is also given diagrammatically with brief notes as to how each individual manoeuvre is best attempted. This chart should be memorised by all prospective stunt pilots.



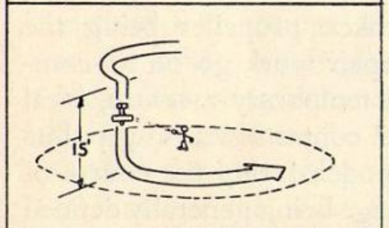
TAKE OFF. With only moderate power available, never pull off sharply with full up elevator, otherwise model may stall. With ample power, take off with up elevator. Do not use down elevator, otherwise model may nose over.



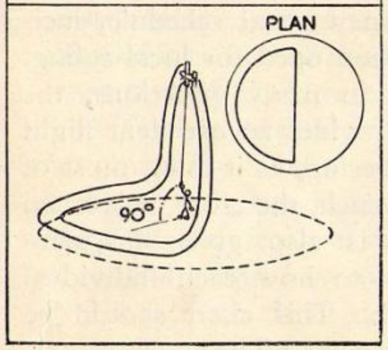
LEVEL FLIGHT. Model will tend to rise when coming round into wind, so correct with down elevator. High level flight requires up elevator to maintain height. Use that amount of elevator necessary to keep constant altitude without lines slackening. All good stunt models will hold a line angle of 60 degrees.



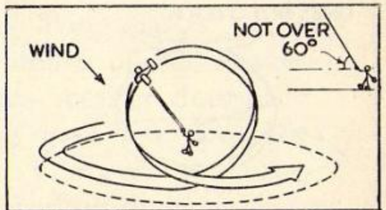
CLIMB. Full up elevator from low level flight, easing off when model assumes vertical attitude. Hold on that elevator necessary to maintain vertical. Recover with full down elevator. Vertical path should be at least 15 feet.



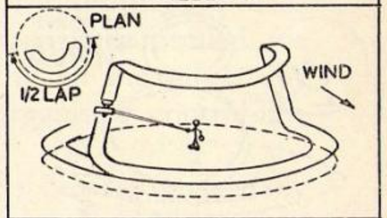
DIVE. Full down elevator from high level flight, then ease off and hold on that elevator necessary to maintain vertical descent. Recover smoothly in good time. Excessive elevator movement in recovery may power-stall model. Judge vertical attitude against suitable background.



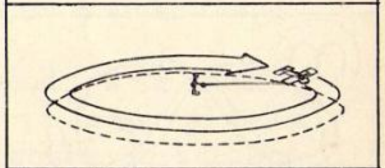
WINGOVER. Full up elevator from low level flight—ease off to vertical climb and hold this attitude. Recover normal flight attitude at bottom of dive with up elevator. Wingovers should be truly vertical with the model passing right over the pilot's head. Lines slackening off at the top of the wingover indicate lack of power, incorrect rigging or too great a line length.



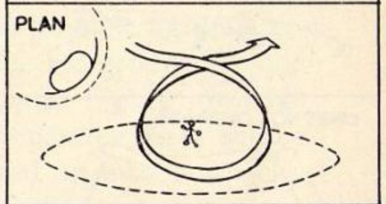
INSIDE LOOP. Put model into a vertical climb and hold until line angle is approximately 45 degrees. Then apply full up elevator and hold on. Recover at bottom of loop. This manoeuvre must be carried out down wind; step back smartly if lines slacken.



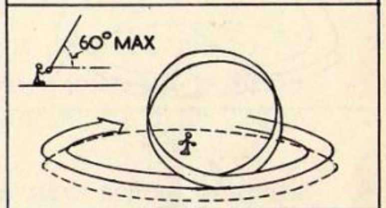
SQUARE INSIDE LOOP. Vertical climb from low level flight. When line angle passes 45 degrees recover to high level inverted flight. Hold inverted flight for one half lap and put model into vertical dive with full up elevator. Recover to normal low level flight.



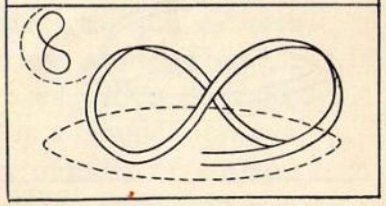
INVERTED FLIGHT. Enter by easing model off inverted from the top of a loop. Practice will be necessary to familiarise pilot with inverted control response. Recover with full down elevator.



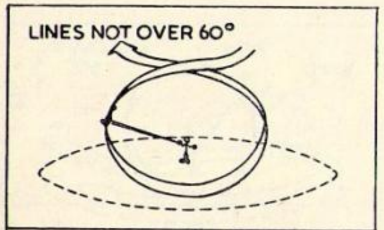
OUTSIDE LOOP (BUNT). From high level flight, apply full down elevator and hold on until model completes loop. It is always advisable to lose speed first by climbing to high level flight and then start bunt.



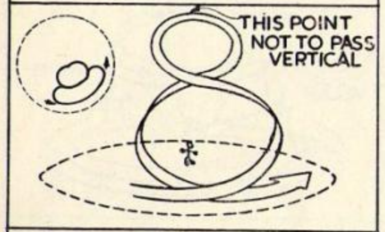
OUTSIDE LOOP. From low level inverted flight, start climb. Apply full down elevator when lines pass 45 degrees and hold on. Recover by easing off down elevator at completion of loop.



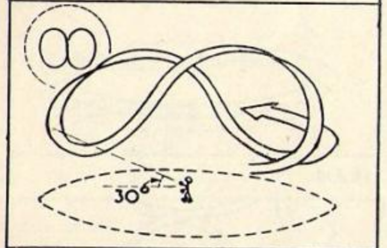
HORIZONTAL FIGURE '8.' A normal inside loop is started from low level flight, but the second part of the loop is turned into an inverted dive by down elevator. Increase down elevator movement to perform an outside loop to complete '8.'



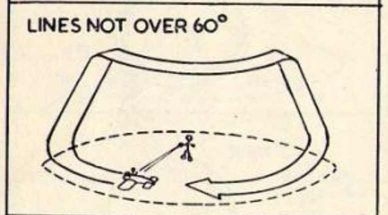
INSIDE LOOP. Started from high level *inverted* flight. Put on full up elevator and hold. Ease off to high level inverted flight again at completion of loop. With a fast or heavy model, an initial climb to lose speed is advisable.



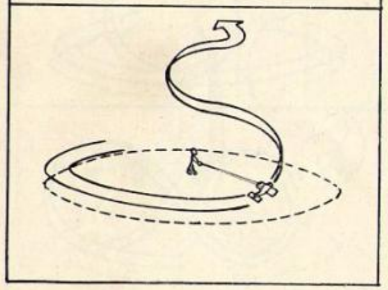
VERTICAL FIGURE '8'. Start with a loop from low level flight. Apply full down elevator at top of loop and hold on until upper loop is completed. Complete bottom loop with full up elevator. Break off manoeuvre at completion of top loop if height remaining appears critical.



OVERHEAD '8.' This is really a combination of two high level wingovers, one inverted. From a normal wingover, down elevator is applied as model passes immediately over pilot's head and held on as necessary. The intersection of the two parts of this figure must come over the centre of the flight circle.



SQUARE OUTSIDE LOOP This manoeuvre is carried out exactly as for a square inside loop, except that it is started from low level inverted flight and controls are reversed. Models require a small looping radius.



VERTICAL 'S.' Start a normal loop from low level flight, then apply full down elevator at top of loop. Model should recover to high level flight rapidly as speed is lost on first part of manoeuvre.

LANDING. Avoid using up elevator after motor cuts, but hold on slight down elevator and pull out level just above ground.

The latest stunt schedule listed by the Society of Model Aeronautical Engineers for the 1949 flying season is very much simplified. Only a selected number of manoeuvres have been retained and the points scoring drastically revised. A further allocation has been left open for special manoeuvres not listed which pilots can nominate.

Although not specifically mentioned on the new stunt schedule, the following points are recommended for attention and will almost certainly be introduced by local authorities responsible for organising control-line contests.

Minimum line length—the figure of 40 ft. is generally adopted as a minimum for contest stunt work, irrespective of the size of the model.

Loss of Points—damage to the model in the course of a competition attempt as defined by a broken propeller where the model will be able to continue with a replacement, will result in loss of points. A possible figure is 25.

Classes—at present all stunt models are grouped as one class for competition work. It seems highly probable —and indeed very desirable—that separate classes will be introduced whenever possible, based on motor capacity and, probably, Senior and Junior.

Inverted flight—all inverted flight manoeuvres to be carried out with the handle upright, i.e. in the position corresponding to normal flight where the " up " line is the top line.

Still to be tried in practice, the new schedule again has its limitations. It certainly makes the judges' task easier and should permit of more close scoring, but the full range of manoeuvres listed is well within the capabilities of any stunt expert. Hence in a competition well attended by leading pilots quite a number of entrants should obtain maximum points on the fixed schedule, leaving the contest result virtually to be decided on the " Special Manoeuvre " class with its allocation of only 15 points. Whether or not it will be possible to arrive at a satisfactory result by such close scoring remains to be seen.

This is, in fact, the main difference between the two. During the 1948 season to the original schedule no competitor ever recorded maximum points, or even approached within several hundred of the maximum. The Nationals was won on a total of 385 points against the possible maximum of 1,030. Completing the full flight pattern to the original schedule was a most exacting task. However, the comprehensive listing of manoeuvres left no scope for individual stunts as does the new list.

It is strongly recommended that pilots who intend to go in for stunt competitions first work up to proficiency on the new schedule (as this will be the basis of the majoity of 1949 contest, at least) and then extend their scope on the lines of the original list, choosing one of the more impressive of the former as their " Special manoeuvre." There are, of course, other manoeuvres not listed which are equally effective, such as the clover leaf, but these we will consider in more detail in a later chapter.

The best method of approaching the stunt schedule during an actual contest is still a matter of some controversy amongst pilots. Some maintain that the best way is to tackle all the manoeuvres giving high points first, so that a good total is piled up quickly. Then, should anything go wrong they have quite a reasonable total. If everything goes well they can complete the small-score manoeuvres at leisure. The opposite attitude is that there is much more chance of crashing during the high-scoring stunts, and hence by starting with the simpler manoeuvres you build up the points total slowly and safely.

CONTEST AEROBATIC SCHEDULE

STARTING

Take-off within 1 minute, 5 points.

TAKE-OFF

Good	5
Rough	3
Poor	1

Maximum 5 points

LEVEL FLIGHT

Two laps at 6 ft. altitude.

Level	6
Wavy	3
Poor	1

Maximum 6 points

CLIMB

To be through 15 ft.

Vertical	10
Steep	7
Shallow	3

Maximum 10 points

DIVE

To be through 15 ft.

Vertical	10
Steep	7
Shallow	3

Maximum 10 points

WINGOVER

Bisecting circuit vertically over pilot.

Vertical	15
Steep	10
Shallow	5

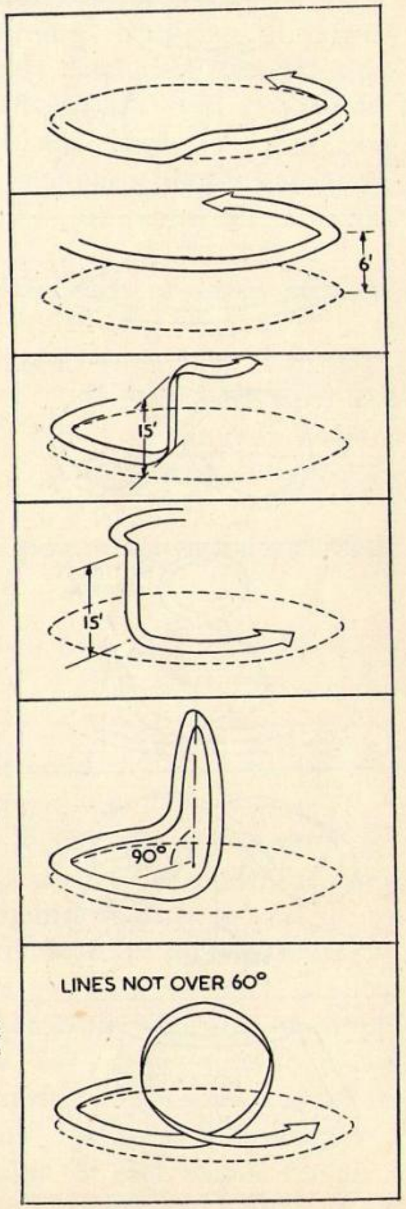
Maximum 15 points

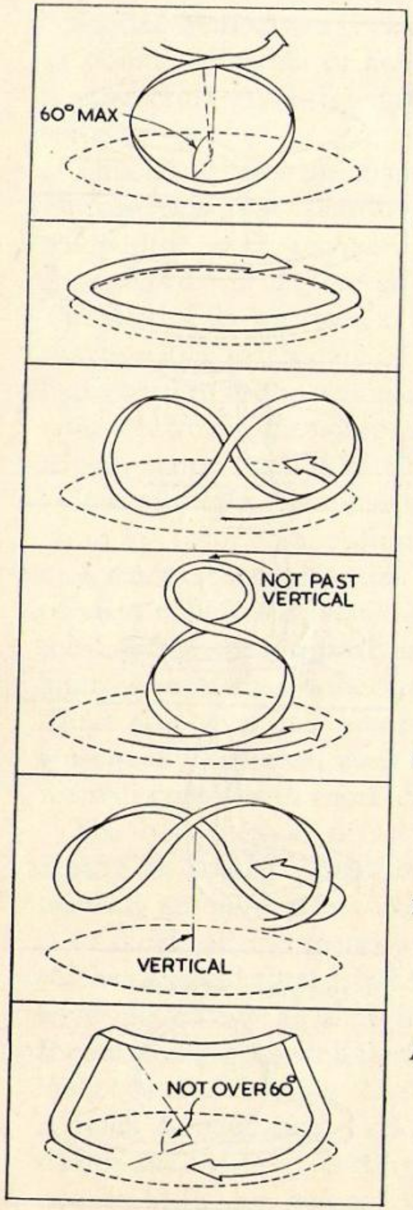
CONSECUTIVE INSIDE LOOPS

To be completed within ½ lap. Line angle not to exceed 60 degrees. Shaky loops lose 2 points each.

1 Loop	3
2 Loops	7
3 Loops	12
4 Loops	18
5 Loops	25

Maximum 25 points





CONSECUTIVE OUTSIDE LOOPS

May be entered from either normal or inverted flight, i.e., J or K of original schedule.

1 Loop	25
2 Loops	30
3 Loops	35
4 Loops	40
5 Loops	45

Maximum 45 points

INVERTED FLIGHT

Direction of circuit opposite to that of normal flight.

1 lap level	10
1 lap wavy	7
2 laps level	15
2 laps wavy	10
Smooth recovery	10
Rough recovery	7

Maximum 25 points

HORIZONTAL FIGURE '8'

To be completed in ½ lap. Shaky manoeuvres lose 3 points each.

1 eight	25
2 eights	30
3 eights	35

Maximum 35 points

VERTICAL FIGURE '8'

Good	30
Rough	20

Maximum 30 points

OVERHEAD FIGURE '8'

Centre of '8' must be immediately over pilot

Good	40
Rough	30

Maximum 40 points

SQUARE LOOP

Horizontal portions of loop to be ¼ lap.

Good	30
Rough	20

Maximum 30 points

SPECIAL MANOEUVRES

As specified by entrant.

Maximum 15 points

LANDING

Good	10
Rough	5
Poor	3

Maximum 10 points

S.M.A.E. Scale Control Line Rules

1. The general rules governing the flying of power-driven models shall apply (including general rules governing control-line flying).
2. Competition entrants shall supply full working drawings of the model, together with a full measurement specification of the prototype aircraft concerned.
3. Points will be awarded in each of seven sections, as follows :—

Absolute scale	20 points	Applicable to *each* of the sub-sections under.
Approximate scale	10 ,,	
Excellent workmanship	20 ,,	
Good ,,	15 ,,	
Fair ,,	10 ,,	

4. Sub-sections, on which points are to be awarded :
   - (i) General appearance.
   - (ii) Fuselage.
   - (iii) Wings.
   - (iv) Tail unit.
   - (v) Landing gear
   - (vi) Motor mount and cowl.
   - (vii) Colour and markings, etc.

   Total possible points $7 \times (20 \text{ plus } 20) = 280$.
5. Once judged for points as above the model must not be altered in any way before flight.
6. All models must fly for inclusion in the contest.

Scoring of Flight Points

Aerobatics—the 1949 Aerobatic schedule to apply (295 points maximum). *One Half* of the points so gained will be added to the workmanship points scored as above. Maximum points 280 plus 295/2—427½ points.

Speed—model scores 1 point for each m.p.h. obtained on a speed run, e.g., 100 m.p.h. scores 100 points, which are added to the workmanship points as above.

As most pilots suffer from nerves to quite an extent during an important contest, starting with the simplest stunts first helps to build up confidence and ease the strain. Thus the actual method is best left to the particular pilot's own temperament. In most cases the stunt schedule will still be open to the extent of allowing the pilot to choose his own *order* of performing the various manoeuvres.

For more advanced stunt work there is still the possibility of flying two models at once and stunting both together. As yet, this has not happened at a British contest, but it is relatively commonplace in important American events. The general ruling then is to give double points for each manoeuvre successfully completed, i.e. each model virtually scores points on the schedule. This ruling may be subject to some modification when contest flying is more advanced over here.

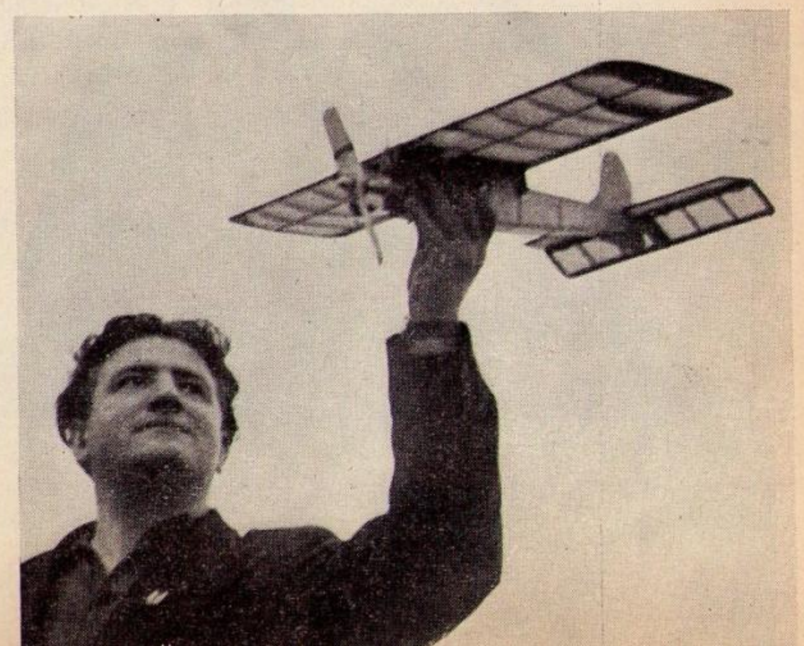
In all stunt contest work the aim should be to do each manoeuvre *smoothly* and *safely*. The first will come solely as the result of practice. Safe contest flying is very much a matter of common sense. For example, no contest pilot would take unnecessary risks. Thus loops and similar manoeuvres would be attempted from a relatively high level—safe flying instead of the spectacular. The latter is more suited to exhibition flying.

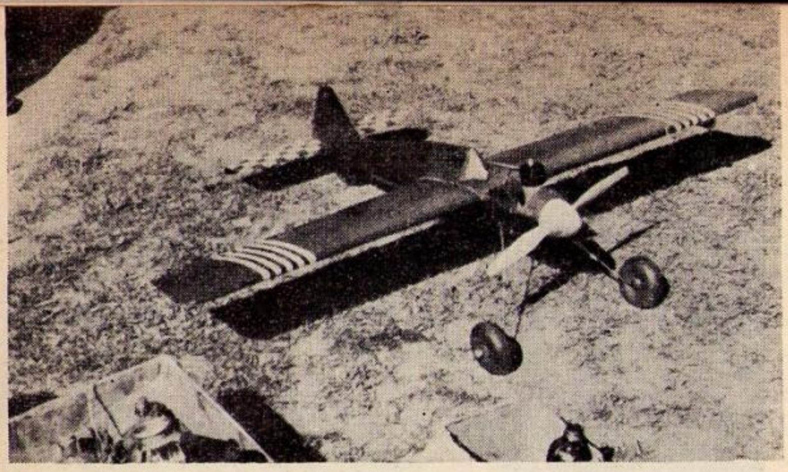
There is actually a very great difference between stunt contest work and stunting for exhibition purposes. To gain maximum points the contest flier must complete all his manoeuvres at the first attempt and complete the flight pattern virtually without incident. To put on a good stunt flying show to thrill spectators, the more incidents the better!

Exhibition flying is definitely better fun. The pilot is not tied down to a set flight pattern. He can repeat

1948 Nationals winner, Pete Cock, did much to popularise small capacity stunt models by beating all the larger machines.

Simplicity of construction is exemplified by this Mills powered stunt model. The built-up elevators are noteworthy.





A large Ohlsson "60" powered stunt model with an attempt at semi-scale appearance. Low weight is necessary for a full stunt range with such models.

Ready accessibility of controls is the first consideration in a general purpose stunt model. The tank installation is clearly defined.

manoeuvres which look good or thrill the crowd; and he can change his mind halfway through a particular manoeuvre, and recover if he wishes, without the fear of losing any points. Flying to a rigid stunt schedule, in fact, tends to make for a monotonous programme. Given a number of real experts, each flight will be very much like the last, each model performing identical manoeuvres.

Further, some of the more advanced manoeuvres listed on the stunt schedule are not necessarily good exhibition stunts. Past-the-vertical dives, pulling out only just above the ground are very thrilling from the point of view of the spectator—probably far more than a number of close consecutive loops at relatively high altitude. Inverted flying, too, is far more impressive if carried out as low as ever possible. The good exhibition pilot would do this—the good contest pilot would fly inverted at a safe height, just in case!

Thus there is considerable scope for the non-competition stunt flier and, once he reaches a good degree of proficiency he may well find that his services are in considerable demand. Control-line model shows and demonstrations are being used more and more as a form of entertainment, from television down to small local fetes.

The technique of flying two models at once demands considerable concentration. Some of the more general points have been mentioned in Book I and in the absence of suitable practical experience there is very little to add to what is given there. Flying two matched models at once in straight and level flight is relatively easy, but even then it is readily possible to get into awkward situations should one model get too far ahead of the other.

Flying speed is more or less constant for a model (apart from loss of speed in severe manoeuvres), and so the simplest way to regulate the *speed of circling* is to fly the slower model at a higher altitude so that its actual flight path per circuit is shorter. In this way the two models can be kept within a short distance of each other and well within the pilot's range of vision.

Stunting two models simultaneously would appear very much a case of " chancing your arm," getting the two as near synchronised as possible and then applying the same control movement to each simultaneously. Loops, bunts and inverted flight should readily be possible with practice for most average pilots.

In case of trouble—and trouble will surely develop sooner or later—it would appear best to jettison one model completely by throwing away the handle and concentrate on saving the other. It will virtually be impossible to bring both under control again—especially if they are going round in opposite directions !

Landing will also be a problem, with one motor cutting before the other and the model slowing right up as a consequence. Obviously the best solution here is to have one model at least fitted with a motor cut-out—if only the one with the longer motor run—when it should be possible to bring in both models together.

CHAPTER IX

THE WINGOVER AND LOOP

THE true vertical wing-over is a very good test for any new stunt model and is also the chief criterion for deciding the maximum length of line possible for any particular machine, as explained in a previous chapter. The general rule is to use as long a line length as possible for all stunt work, but not so long that the lines slacken right off at the top of a wingover and control is lost, momentarily at least. The maximum safe length for a wing-over is considerably shorter than that for maximum line length for looping.

The wing-over is shown in Fig. 66 ; this is as it appears to an observer outside the flight circle. For best effect, it is started from low level horizontal flight, pulling the machine up into a vertical climb and holding it so that the model passes right over the pilot's head, down the other side to be pulled out level again.

Adequate power is the first essential for a successful vertical wing-over, coupled with correct rigging of the model to maintain line tension at high altitude. The vertical climb part is simply started by giving full up elevator and then easing off as soon as the nose of the model is pointed straight up. The model is held in the position corresponding to a true vertical climb, so that it passes right overhead. Recovery is simply by applying up elevator again at the bottom of the ensuing dive. A model with over-powerful controls may tend to stall or mush if pulled out too rapidly at the bottom of the dive. A properly designed and balanced stunt model should snap round to level flight smartly, when controls must be neutralised to prevent the model climbing again.

To be effective (and to gain full points in contest work) the wing-over must be truly vertical. A sloppy wing-over of appreciably less than 90 deg. looks poor and is an indication of lack of ability on the part of the pilot, or the model or both. The poor wing-over is regarded as the beginners' method of departing from straight and level flight.

From the pilot's point of view, the flight pattern of a wing-over is quite different from that shown in Fig. 66. It is a little difficult to represent this diagrammatically, since the pilot is moving round all the time with the model during normal flight and so the only logical way to represent manoeuvres as they appear from the centre of the circle is to imagine the flight pattern of Fig. 66 and similar drawn on the inside surface of a hollow cylinder with this cylinder then flattened out into the form of a rectangle with no background. As far as the pilot is concerned, the background should not enter

FIG 66

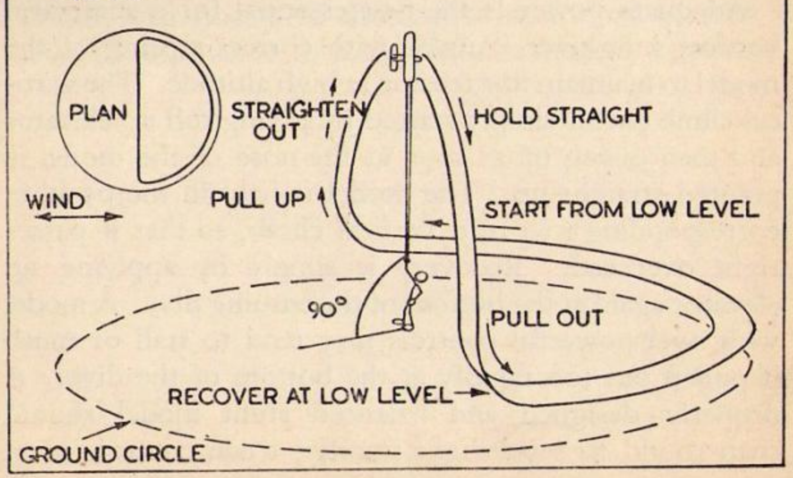
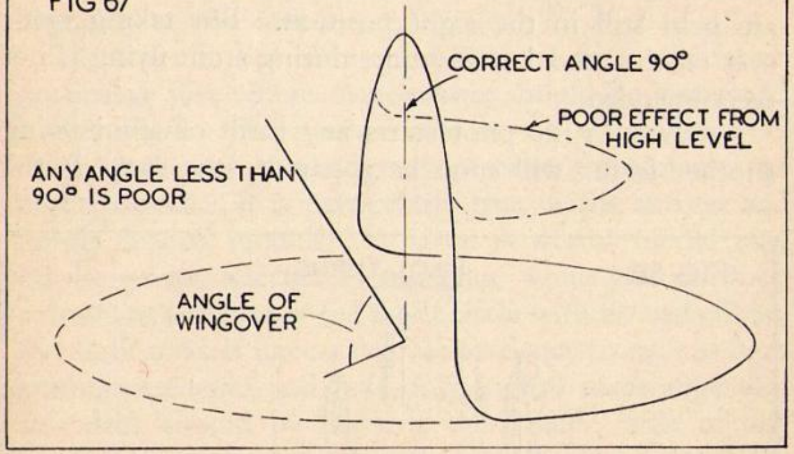


FIG 67



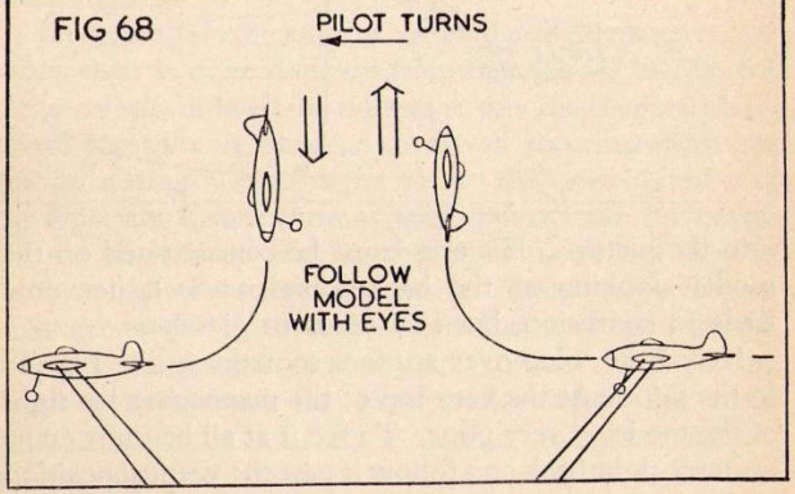
into the picture. His eyes must be concentrated on the model—looking at the background as well not only leads to confusion, but also tends to giddiness.

Hence the wing-over appears something like Fig. 68 to the pilot. At the very top of the manoeuvre his sight of the model is very poor. To see it at all he must crane his neck right back and follow it past the vertical position with a quick turning movement. With a large model on long lines, particularly, it is not unknown for the pilot to lose sight of the model entirely for a fraction of a second or so. Also, with the model dead overhead, it is not always easy to judge whether the model is truly vertical or not—or even which side of the model he is actually looking at! The only reference the control-line pilot has for lining up his model—the horizon—is absent in high level flight and hence a certain amount of knack akin to "flying by the seat of one's pants" must be acquired.

Not that the wing-over is a difficult manoeuvre. Given the right model, it is one of the easiest and a good stable job will fly itself over the top provided the controls are held still in the right position. But taking one's eyes off the model at any time during stunt flying is not recommended.

As soon as the pilot starts any form of stunt flying another factor will soon be apparent—the sun. If the

FIG 68



weather is clear, then the sun can be extremely disturbing Following a model carefully through a manoeuvre such as a wing-over the pilot momentarily finds himself gazing directly into the sun, with the result that for the next few seconds he can see nothing at all clearly. During those seconds he might well lose control of the model and crash.

The best remedy for " sun trouble " is undoubtedly sun glasses, and these are a valuable accessory to the control-line pilot. Failing that he can, of course, adopt such dodges as shutting one eye when looking near the sun and opening it again immediately afterwards, or

doing his manoeuvres in that part of the flight circle opposite to the sun.

The latter is not always possible, as the main factor governing just where manoeuvres should be attempted is the wind. The general rule is, do all manoeuvres downwind, and this is good practice throughout the flight pattern. It is particularly true of the smaller and lightly loaded models. A large powerful model may not be greatly affected by moderate winds and can loop or stunt at any part of the flight circle with no bad effects. But light models have a definite tendency to drift at high altitudes in wind and it is only logical to arrange that this drift should be towards the " safe " side of any particular manoeuvre. In the case of a wing-over, the " safe " side is obviously that tending to flatten the wing-over out and the arrows in the previous diagrams show best wind direction.

Flying in wind can be troublesome, even with the best of models, and is not generally recommended. Where the wind is particularly strong or gusty, and much control-line flying is done from small fields where surrounding obstructions aggrevate gusts, the model will continually be changing groundspeed, which has its effect in varying the pull on the lines. This makes the pilot's job more difficult and demands considerable skill to overcome and still make all manoeuvres smooth. He has to be continually on the alert to correct for gusts. In the writer's own experience the pull on the downward side of the circuit with a large and heavy model can be prohibitive in a stiff breeze.

From the competition point of view, weather is an unknown quantity and the competition flier must be prepared to be able to fly in all sorts of conditions, hence practice in poor conditions is most valuable.

Returning once again to the wing-over and analysing the possible faults which may develop. Line length for practice flying should be that specified in Chapter VII for stunt work, or about 5 ft. shorter for initial test flights with a new machine. As far as possible, always fly stunt models on "competition" line lengths, and, equally applicable, never fly on unnecessarily long lines. Actual weight of lines is quite unimportant, irrespective of length, but line drag is extremely high and the less drag the more power available for actually manoeuvring the model. Contrarywise, short lines not only make stunt flying look ridiculous but do not give a true test of ability.

If the model begins to slacken off the lines in the vertical climb part of a wing-over as soon as the lines have exceeded an angle of about 45 deg., then the fault is almost certainly lack of power. Under such conditions it is strongly advisable to recover to level flight immediately. If the motor is just incapable of giving more thrust (tried with a variety of propellers) and is of the right size recommended for the size of model, then the fault probably lies with the model. A more powerful motor will almost certainly cure the trouble, but moderately-powered stunt models can be highly successful.

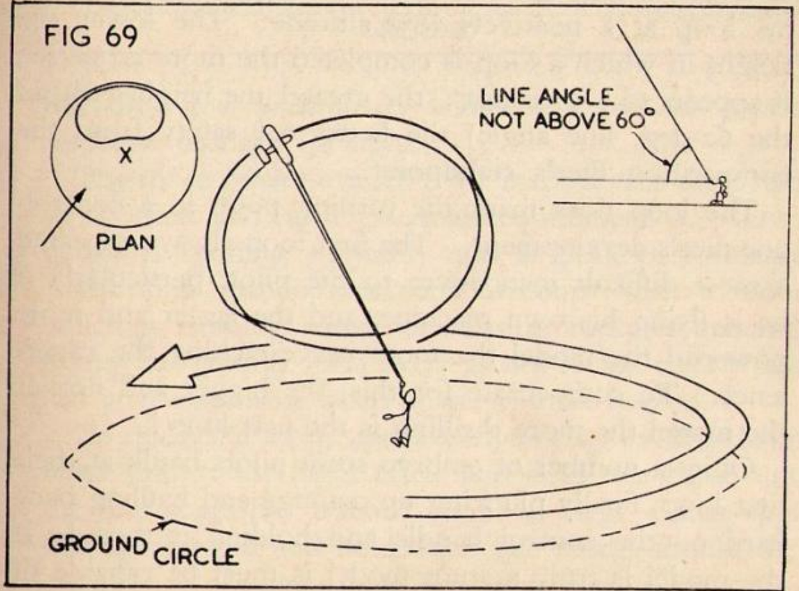
Check first the various factors affecting line stability (Book I), increasing rudder offset, motor side thrust, or similar adjustment and try again. If the results are similar, then the only thing to do with that particular model is to shorten the lines (assuming here that the lines used are similar to those specified for stunt work, i.e., steel lines of between 0.008 and 0.012 in. thick, depending on the size of the model). The other "cure" is more drastic, and may need considerable modification to the airframe, reducing the wing loading by reducing

the total weight. One of the few instances where this is readily possible is if a spark-ignition motor is being used, when the ignition accessories can be removed and the motor operated with glow-plug ignition. The simplest solution of all is, more power!

A model which will wing-over successfully will almost certainly loop, but before attempting a loop with a new model always check that adequate elevator movement is present, 30 deg. up being the minimum required for safety. On some models it is possible to distort or displace the control system by accident—a fairly moderate blow on the elevators, for example, may bend the control horn, with the result that the elevator range is not matched to the control plate position. A quick check before each flight is a sure safeguard against such troubles.

The loop appears to the spectator as in Fig. 69.

FIG 69



To be most effective it must be started from low level flight and made of fairly generous radius, although the line angle should never exceed 60 deg. This is specified in the stunt rules as one of the requirements for competition work; above a 60-deg. line angle a loop can become virtually a form of wing-over.

The pilot's view of the loop is more flattering than the spectator's. To him, the model remains at a constant distance from his eye and the loop is apparently in the vertical plane, Fig. 70. Exhibition fliers particularly should study this point. What to them may seem a good loop may appear most unimpressive to the spectator outside the circle.

Looping technique varies for stunt and exhibition work. In the former case the pilot plays safe and starts the loop with ample height in hand in case the pull out and recovery is prolonged. The exhibition flier cuts safety to fine limits and aims to both start and finish his loop at a relatively low altitude. The lower the height in which a loop is completed the more attractive it appears to a spectator; the greater the height (within the 60-deg. line angle) the better for safety from the competition flier's standpoint.

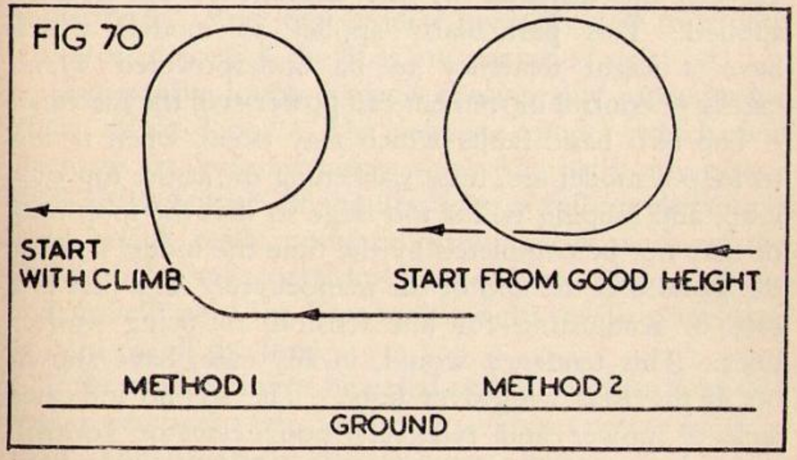
The loop does mark the turning point in a control-line flier's development. The first loop always appeared a most difficult manoeuvre to the pilot, particularly if he is flying his own machine, and the larger and more powerful the model the more nerve-racking the experience. To compensate for this, the bigger and noisier the model the more thrilling is the first loop!

Quite a number of embryo stunt pilots baulk at their first loop, finally plucking up courage and hauling back hard on the control handle and holding it there! If the model is truly a stunt model is must be capable of

looping, and the sooner it is made to loop the better, to justify the design at least!

First attempts at loops should be made in relatively calm conditions. The less wind the better. If there is any wind, then the only place to attempt loops is dead downwind. Line stability of the model can be tested

FIG 70



fully by a few preliminary wing-overs and the control response checked in flight.

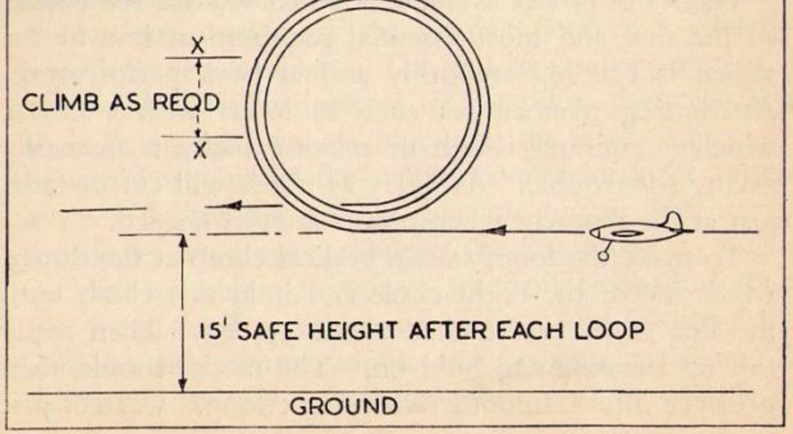
The more power available for manoeuvres the better, so the first and most essential requirement is a motor which is running smoothly and at peak performance. Attempting manoeuvres such as loops with a motor which is running rough or missing badly is generally asking for trouble. As likely as not it will cut or fade. just at the moment when power is most needed.

To make the loop, start a vertical climb at the downwind side of the flight circle and hold this climb until the line angle has reached about 45 deg. Then apply full up elevator and hold on. The model should then go over into a smooth rather tight loop. Correct just before the bottom of the loop, otherwise the model may power stall or mush on coming out of a dive with full up elevator.

Having once completed a loop, the rest is a matter of practice. Instead of holding on full up elevator throughout most models can be smoothly flown around a loop, varying the diameter by the amount of up elevator applied. This particularly applies to models which have a slight tendency to be underpowered where excessive control movement can power-stall the machine.

The two basic faults which may occur when trying to loop a model are, lines slackening off at the top of a loop, and looping radius too large so that the loop may or may not be completed by the time the model reaches the ground at the end of the manoeuvre. The first is a case of readjusting for line tension, or using shorter lines. This tendency would, in any case, have shown up in previous wing-over tests. The second indicates lack of power and relatively poor elevator control. Again increase in power is the most satisfactory solution,

FIG 71



but check again that the elevators are of the correct area relative to the wings and have the full range of movement required.

If the lines do slacken off, of course, during looping or any similar manoeuvre, immediate action must be taken. The only thing to do is to move back smartly until the slack has been regained and full control is available once more. Very few models normally will trim with elevators neutral if the lines are slackened right off.

Consecutive loops demand considerably more power than single loops. The average model which will perform single loops quite successfully will only power stall at the bottom of the first loop if full up elevator is held on. A really powerful stunt model, such as the "Boxcar," will perform consecutive loops almost indefinitely until the lines tangle right up if up elevator is held on all the time.

If the model cannot be eased out of the first loop and then taken over again, and so on, without power stalling, then about the only cure is more power.

Even with powerful models it happens sometimes that the elevators are more powerful than is necessary (e.g., have too great a range of movement) and a power-stall can result, so that best practice here is to fly the model over each loop with only that amount of elevator movement necessary for safety, easing out the climb part each time to gain a little more height, see Fig. 71. Flying a model over a series of loops is infinitely more satisfactory than simply holding on up elevator and letting the brute force of a really powerful motor do all the work.

The loop is the basis of a number of other manoeuvres and should be thoroughly mastered by constant practice. Looping characteristics will vary considerably with different machines, and particularly with different types. A long-moment arm model, for example, will feel and react differently from one with a short moment arm, but the reactions necessary to give perfect, smooth flying are mastered readily by practice and become instinctive. Smooth flying is, above all, the mark of a first class stunt pilot.

CHAPTER X

ADVANCED MANOEUVRES

HAVING mastered the loop, the average pilot is anxious to go on to further and more intricate flight patterns, particularly if the model has shown itself capable of looping readily in a relatively small radius. Almost certainly a model which will do consecutive loops will do most other stunts on the standard flight pattern.

The horizontal figure eight is the next logical step after the loop, Fig. 72, especially since here only moderate power is required. That is to say, a model which will do one loop only will generally fly horizontal eights quite successfully.

The flight pattern from the pilot's viewpoint is quite simple, although a fair amount of practice is needed to get smoothness, with one loop of the eight flowing smoothly into the other. First attempts are generally very ragged and asymmetric. The properly flown eight has both loops of equal diameter, with the model flying a constantly changing curved path all the time.

The conventional way of flying this manoeuvre is shown in Fig. 73, where it will be seen that it is started with a loop, straightening out as the model passes over the top of the loop and then using plenty of down elevator to complete the figure eight with an inverted loop. For smooth flying it is necessary to fly the model right through this manoeuvre. Full up elevator for the first loop and then full down at the appropriate point for the second part will not usually produce a particularly smooth or pleasing flight path. Here the practice obtained in *flying* the model round a loop, as

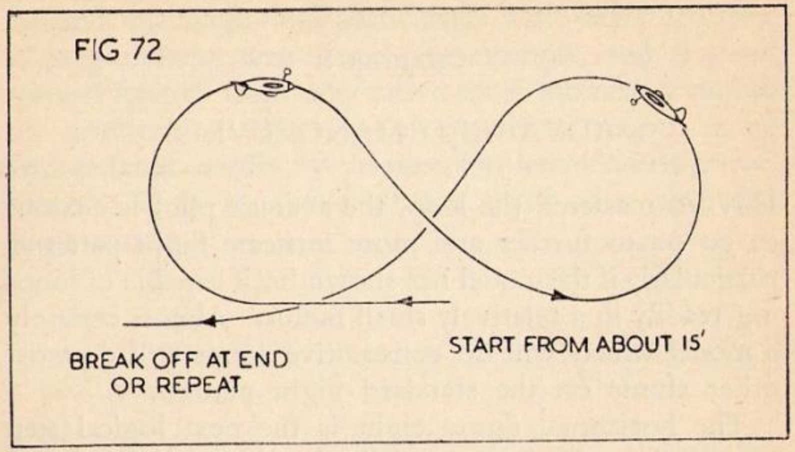


FIG 72

described in the previous chapter, will be of great help.

Since no excess power is needed for horizontal eights this manoeuvre can be repeated over and over again. Consecutive horizontal eights do, in fact, appear on the new stunt schedule, although only single eights were specified on the original.

Although this manoeuvre does not really bring in inverted flight conditions, it does involve a bunt or inverted loop carried out with a large down elevator movement. Some modellers find this difficult to master

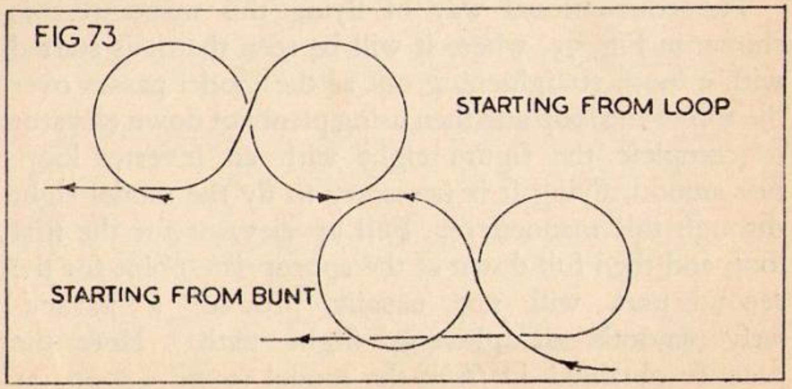


FIG 73

at first. They may put on full down elevator quite readily, but some instinct or other tries to make the tyro pilot ease this off, when the results can be disastrous. Therefore, concentrate hard when flying this pattern for the first time and do not let subconscious reaction overcome commonsense. Eights will become

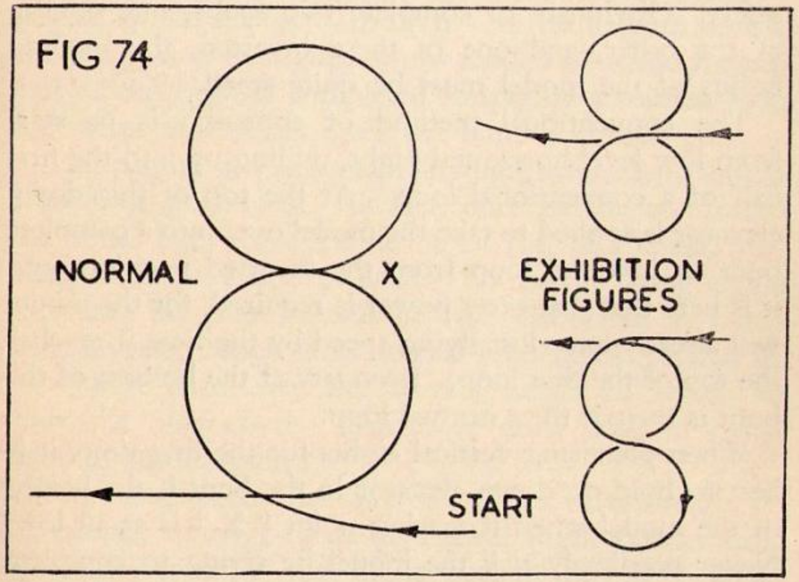


FIG 74

just as instinctive as other simple manoeuvres with practice.

As a variation, the horizontal eight can be tackled in other ways, one of the most spectacular being shown in the second diagram of Fig. 73. Instead of starting with a loop, the pilot here climbs to lose flying speed and then puts the model over into a bunt with full down elevator (or nearly so). Pulling out into a normal loop completes the manoeuvre.

This method is probably not so good for competition work as there is more risk of crashing in a bunt than a loop, but it has the advantage of leaving the relatively simple loop as the last part of the figure which can be completed to match the first part more accurately. Most pilots regard it as a better exhibition figure.

The vertical figure eight, Fig. 74, is considerably more difficult and does demand a really powerful motor for safety. Obviously to complete two loops, one on top of the other, and one of these inverted, the looping radius of the model must be quite small.

The conventional method of approach is to start from low level horizontal flight, pulling up into the first half of a conventional loop. At the top of this down elevator is applied to take the model over into a complete bunt or inverted loop from the inverted position, and it is here that that extra power is required, for the model will already have lost flying speed by the time it reaches the top of the first loop. Recovery at the bottom of the bunt is then as for a normal loop.

When practising vertical eights for the first time, it is best to hold on down elevator in the bunt if the height of the model when it reaches point " X " is at all low. Never needlessly risk the model by trying to complete the manoeuvre with insufficient height in hand. If down elevator is held on the model will go over into another bunt and can be recovered to normal high level flight and another attempt made. The writer, in fact, when practising this manoeuvre for the first time never tried to complete the whole eight at first, but concentrated mainly on the top half of the figure.

This manoeuvre is beyond the capabilities of certain otherwise excellent stunt models and this will show clearly if there is insufficient power to complete the top inverted loop. In such cases it is unwise to risk serious

damage to the model in trying to fly it round the pattern in a semi-stalled condition. It will not, in any case, climb if power stalled.

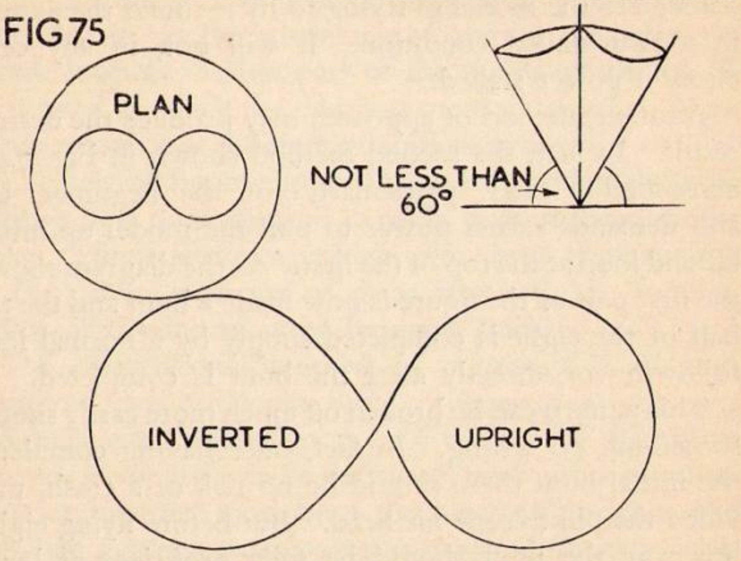
Another method of approach may produce the desired result. In fact, the second method shown in Fig. 74 is considerably safer, particularly for the beginner, but still demands excess power to pull the model up into a second loop at the top of the first. As the diagram shows, the first part of the figure is now made a bunt and the top half of the eight is completed simply by a normal loop following on directly after the bunt is completed.

This pattern can be broken off much more easily should something go wrong. In fact, once having completed the initial bunt there should be no risk of a crash, provided the pilot keeps his head. But before flying eights this way the pilot should be fully proficient at bunts (i.e., inverted loops from normal level flight) so that he can judge accurately the correct height at which to start the manoeuvre. Bunts are dealt with in detail later in the chapter.

The most spectacular way of doing a vertical eight is, of course, to start from high level flight downwards, virtually inverting the flight pattern of the original figure. As an exhibition piece this can be most effective, but for competition work it will pay to go about it in a safer way.

The other " eight " pattern recognised as a standard manoeuvre is the overhead eight, with the intersection of the loops of the eight immediately over the pilot's head. For this manoeuvre the line angle must not drop below 60 deg., see Fig. 75. The overhead eight is virtually a high altitude loop, turning into a high altitude bunt. With a model having good line stability and ample power it can be repeated indefinitely.

FIG 75



INTERSECTION RIGHT OVER PILOT

Normal high altitude circuits are good practice, climbing the model as far as it will go readily and doing tight circles right above the pilot's head. This will accustom the pilot to viewing the model right above himself and most probably he will now notice that he tends to get giddy after a few laps. This is because he is turning quite rapidly since the diameter of the flight circle is so small. A cloudy sky will aggrevate giddiness by providing a disturbing background.

Preferably the pilot should have a good experience of inverted flight before trying overhead eights, as this will help him considerably should he get into trouble on the last part of the manoeuvre. However, this is not essential.

First practise very high altitude loops, trying to get the top of the loop to come immediately overhead.

Unless the model is stable and has plenty of power, there will be a definite tendency for the lines to slacken when, as in most other cases (assuming sound design) a more powerful motor is the answer.

Once high loops have been thoroughly mastered it remains to try the eight itself by applying down elevator as the model comes overhead and flying it round a high altitude inverted loop to come overhead again, recovering with up elevator into another high altitude loop and so on, or to normal level flight as desired If the lines go slack on the inverted part of the eight, the best action is to put on full up elevator and run backwards smartly away from the model, thus taking up line tension again and recovering the model as from the top of a normal loop. Always be prepared to move back in such manoeuvres to take up slack lines should this be necessary.

Some proficient stunt pilots can carry out consecutive overhead eights by lying flat on the ground looking directly up at the model. This, in fact, is considerably easier than standing upright and looking almost directly upwards all the time, but recovering oneself from the horizontal to the vertical and vice versa, is itself no mean feat and not generally recommended!

This then covers the recognised figure eight manoeuvres with control-line models. The majority of the other advanced manoeuvres are directly concerned with inverted flight and are dealt with in the next chapter, including square loops which depend upon inverted flight proficiency. Of the other manoeuvres which will be dealt with here there are two which appear on the original stunt schedule, the vertical " S," and another which is not recognised as a standard manoeuvre, but frequently is used as a special stunt, the clover leaf.

The vertical " S " is relatively simple to fly, but does demand a good stunt model. The simple approach is from low level flight upwards, Fig. 76, starting a loop and then pulling off at the top into half a bunt, coming out into normal high level flight. The lower down this manoeuvre is started, the better.

The vertical "S" downwards demands precise judgment of altitude and thorough familiarity with the model as regards its looping radius. The first part is half a bunt, which brings the model out into inverted level flight. Immediately up elevator is applied to complete the latter half of a normal loop, recovering the model at normal low level attitude.

The danger is obvious. The first part of the manoeuvre may use up so much height that the second half loop is impossible and it is here that experience in judging heights is necessary. The last half loop will, in any case be of wider radius than usual because the model will

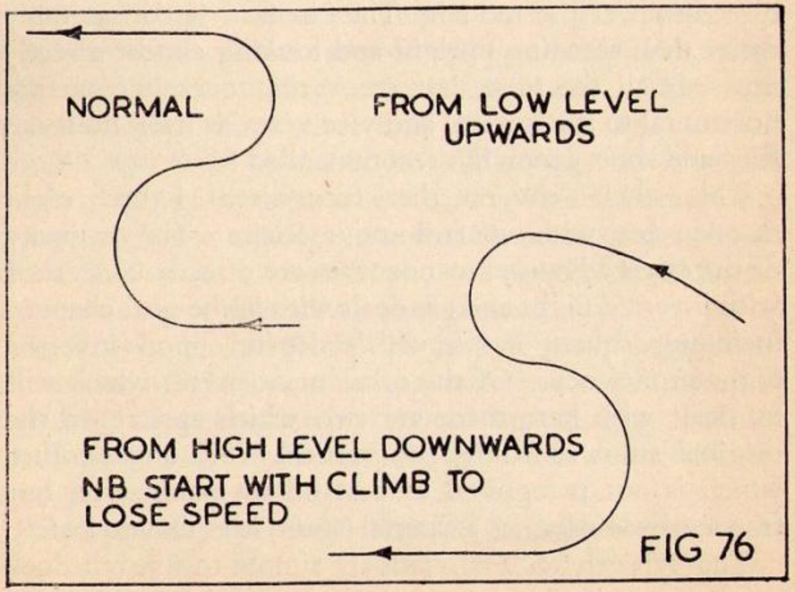
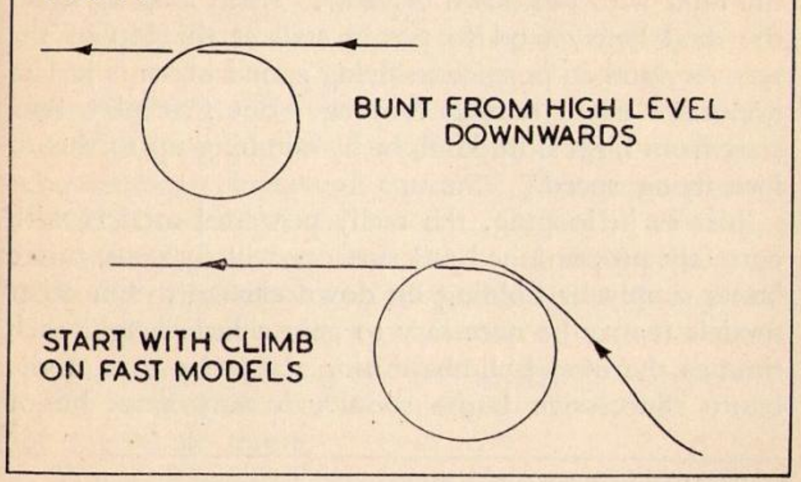


FIG 76

FIG 77


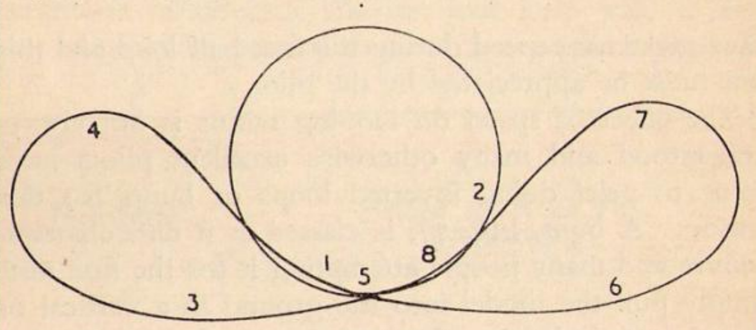
have picked up speed during the first half loop and this fact must be appreciated by the pilot.

The effect of speed on looping radius is not always understood and many otherwise excellent pilots have come to grief doing inverted loops or bunts for this reason. A bunt, Fig. 77, is classed as a difficult manoeuvre and many people attempting it for the first time simply pull the model into the ground in a vertical or past-the-vertical dive. One of the reasons for this has already been mentioned, the subconscious reaction to holding on full down elevator, the other is that, particularly with normally fast flying models, speed picked up during the first part of the bunt greatly increases the looping radius. Lack of power and/or insufficient elevator power may be contributory causes, at least 30 deg. down movement being necessary on the latter, as for normal looping.

Usually the safest way to start a bunt is first to climb so that the model loses speed and then go straight into the bunt with full down elevator. As in looping again the model may tend to power stall at the top of the recovery and so practice in flying round bunts is just as important as in normal looping. But first play safe, start from high altitude flight by climbing up to this to lose flying speed.

Just as in looping, the really powerful models with correctly proportioned tail surfaces will fly consecutive bunts simply by holding on down elevator. On other models it may be necessary to gain a little height each time as the model climbs during the latter part of the bunt. Successive bunts should, in any case, be of

FIG78 CLOVER LEAF



BREAK OFF OR REPEAT AT 8

reasonably small diameter since a lot of flying speed will have been lost during the initial manoeuvre. Successive bunts are not possible without plenty of power.

The final manoeuvre to be described here, the clover leaf, is shown in Fig. 78. This is really a flattened horizontal eight with a normal loop thrown in in the middle. There are several methods of flying this

pattern, but the one shown is the most straightforward and the least likely to lead to trouble.

A single conventional loop is first flown and from the recovery at low level the model is put through an elongated and slightly distorted horizontal eight. The eight actually curves upwards so that the three loops form a conventional clover-leaf pattern. This manoeuvre is, in fact, extremely good practice, for, to be effective, it must be flown very smoothly and accurately. Any jerkiness or poorly-shaped loops will be readily apparent, but since the pilot will be concentrating on each separate loop in turn he should also have a spectator outside the circle to give him an independent view of the quality of the whole figure.

Throughout the chapter very little emphasis has been placed on procedure should the lines slacken off during manoeuvres for, with a good model, properly rigged and with ample power, line slackening is the exception rather than the rule. It should be possible to fly out the whole of the stunt schedule without having to move to take up slack lines. If not the fault lies either with the model itself, or with the pilot in not flying out the flight pattern correctly. Smaller and lightly loaded models may not strictly conform to this, particularly if there is any wind, but even in these cases poor line tension is often an indication of some inherent fault in the model—and usually the same answer as before, lack of power.

CHAPTER XI

INVERTED FLIGHT MANOEUVRES

STRANGELY enough, the beginner to control-line flying who starts with a stunt model generally has less difficulty in mastering inverted flight conditions where the controls are inverted than the more experienced " sports " flier who has many hours of control-line flying to his credit. The latter has learned to fly by instinct, by constant practice, and his reactions to any displacement of the model are purely subconscious. However, his previous practice has been confined to normal flight, with possibly a few loops and similar straightforward manoeuvres thrown in. When it comes to learning inverted flight control his previous experience has been so well absorbed that he will, instinctively, time and time again make an " instinctive control movement," which is just the opposite of that required.

The stunt pilot is recommended strongly to fly on the standard principle of learning reversed control movement rather than adopting such methods as inverting the handle or using special " trick " handles which invert the lines as the model is inverted, particularly as it appears that all such practices will be banned for future competition work. The principle of inverted control is then simply " Up is Down and Down is Up," Fig. 79.

Almost certainly the first time a pilot takes a model over on to its back and starts inverted flying he will get into trouble, however much he concentrates on this general rule and practice and plenty of it is the *only* method of securing proficiency. Some very ingenious methods have been suggested for producing inverted

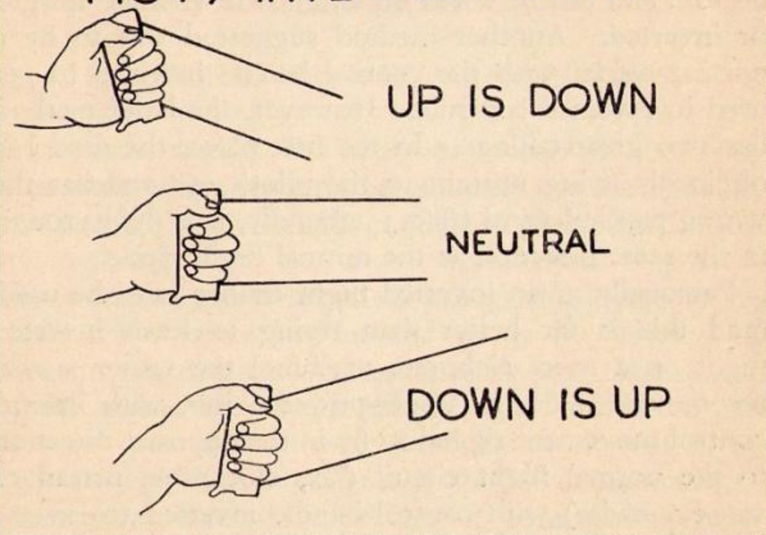
flight trainers which have an undercarriage on top and bottom and can be taken off and flown whether upright or inverted. Another method suggested was to fly a normal model with the control handle inverted to get used to reversed controls. However, the latter method has two great failings. In the first place, the model is obviously flying upright to the pilot's eye and has the wrong psychological effect ; secondly, it is flying round in the same direction as the normal flight circle.

Personally, if an inverted flight trainer is to be used (and this is far better than trying to learn inverted flight on a more elaborate machine) the writer would recommend a docile, under-powered job, with limited control movement rigged to fly in the opposite direction to the normal flight circuit (i.e., clockwise instead of anti-clockwise) with control handle inverted to reverse the controls, see Fig. 80. To complete the illusion a drop-off undercarriage can be used. Once the pilot has mastered the technique of " Up is Down and Down is Up " control movement can be increased and steep dives and climbs practised, still with inverted controls.

For straightforward inverted flying a simple rule to remember is to follow the model with the arm holding the control handle. Thus if the model climbs, follow it by pointing the arm upwards towards the model. This will automatically correct and level off the model again. (This, it will be noticed, is directly opposite to normal flight conditions where in learning to fly the rule is to point the arm to where you want the model to go, i.e., raise the arm to induce a climb, and so on.)

Flying inverted the pilot must consciously think out each manoeuvre (" Up is Down and Down is Up ") and correct any climbing or diving tendency with small amounts of elevator movement. In fact, it is quite a

FIG 79 INVERTED FLIGHT



good plan to stop down elevator movement a little if the full 45-deg. up and down movement is originally used on the model, but not stopped down too much so that it is impossible to take the model over into the inverted flight position from normal flight. Stopped down controls should, in any case, be used only until the pilot is reasonably proficient at holding the model straight and level in inverted flight and performing mild climbs and dives and correcting smoothly.

Generally it is when something unexpected happens that the pilot tends to lose his head and apply " instinctive " control action and overrule his knowledge that the controls are, in fact, reversed. A " correction " is made hurriedly and instinctively, in the wrong direction.

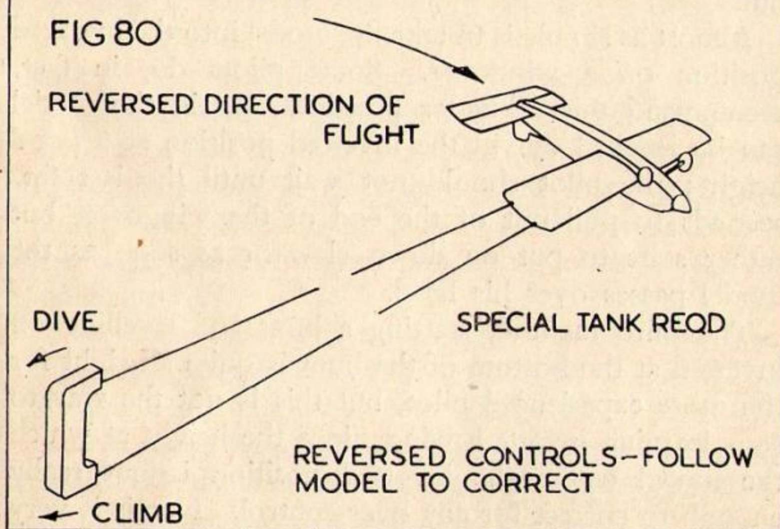
Almost all crashes from normal inverted flight are the result of inverted dives, because up elevator was applied instead of down. Therefore the main thing to

remember is to go very steadily with the normal up elevator movement. In fact, avoid using up elevator as much as possible (which in inverted flight produces a dive) until thoroughly familiar with inverted technique.

A stunt pilot must also overcome that inherent reluctance in some people to put on full down elevator and hold it. Wrist or arm movement corresponding to down elevator is a less natural movement than that giving up elevator.

Particularly when he first starts practising inverted flight, the pilot will inevitably get into trouble and he may save himself quite a number of crashes if he memorises the one over-riding rule, in case of trouble when inverted, put on full *down* elevator and hold it. Since most troubles do end up in an inverted dive this should recover the model and bring it right round in a bunt from the inverted position, when a normal recovery to level flight can be made at the top of this bunt.

FIG 80



No further text-book instruction on inverted flying can be of very great help to the learner-pilot. The ultimate solution lies in his own hands, worked out the hard way by actual flying practice. But this need not prove particularly difficult or expensive if he can keep his head and think out what he is doing. Also it is recommended strongly that one of the smaller classes of stunt models be used for inverted training as these are far more crash-proof than the larger and heavier jobs. A model like the "Vandiver," "Playboy" or "Stuntmaster" will more than repay the original cost of the kit in this respect.

The easiest and probably the safest way to enter inverted flight is to pull the model up as for a normal loop and then level off at the top in the inverted position simply by neutralising the elevators. This gives the maximum possible altitude when entering the inverted position, with a correspondingly better chance of recovering from any over-control in levelling the model out.

Almost as simple is to take the model into the inverted position off a wingover. Some pilots do, in fact, recommend this as better practice. Again the model can be levelled out in the inverted position at a good height; the pilot should not wait until the last few seconds to pull out of the end of the wingover, but rather start to put on down elevator as soon as the model passes over his head.

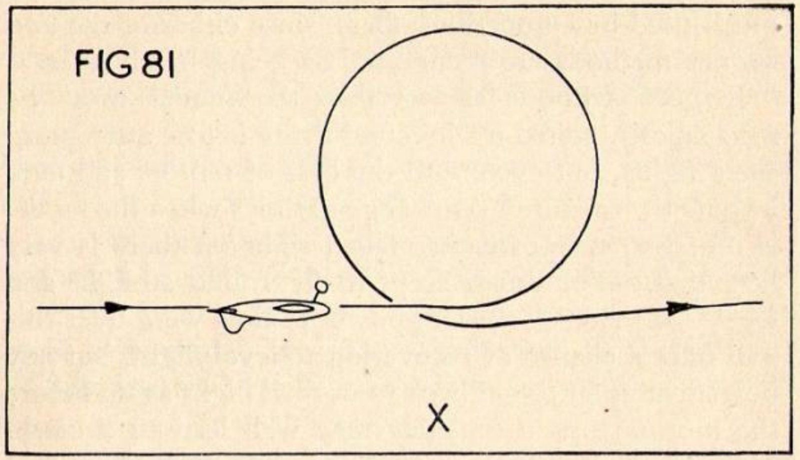
The third method, starting a bunt and levelling off inverted at the bottom of the bunt is quite all right for the more experienced pilot, but this is not the way to start learning inverted flying, since the height at which the model enters the inverted position is not really enough to correct for any over-control. Nor is it very

much used by competition fliers, since either of the two former methods are recognised as being much safer.

It goes without saying that the model must be mechanically suited for inverted flying before attempting such flights, but even with the best of motors and tank layouts the mixture may change at times when the model is inverted. If power has fallen right off there is very little that can be done except to fly round straight and level. If there is sufficient power to do a wing-over this will offer a chance of recovering to level flight, but any hurried attempt to get back to normal flight again before the motor stops completely may well lead to a crash. If in doubt, it is better to carry on and land the model inverted. The resulting damage, if any, will be considerably less than that resulting from a dive into the ground or a power stall and lines slackening off through trying to complete a half loop with insufficient power.

If the motor stops in the inverted flight position the model *must* be landed inverted. It is quite impossible to bring it back to level flight without power. You cannot dive the model with power off, for example, and pick up sufficient speed to complete a half loop. The model will simply stall and crash out of control, for after a power-off stall the lines will almost certainly slacken right off. Remember that the motor is the chief factor giving line tension by virtue of the speed it gives the model (and outward pull of an offset thrust line, where used).

So much for the basic elements of inverted flying. Once the pilot is reasonably proficient at control and no longer lets instinct over-rule his reactions he can go on to attempting any of the flight manoeuvres normally carried out from the normal flight position. An upward loop from the inverted position, Fig. 81, is, for example,



similar in effect to a bunt as regards control movement, but similar to an ordinary loop from the appearance of the flight pattern. The new stunt schedule does, in fact, state that a bunt can be carried out from normal flight downwards, or from inverted flight upwards. Given the choice, the latter method is probably safer once inverted flight technique has been mastered.

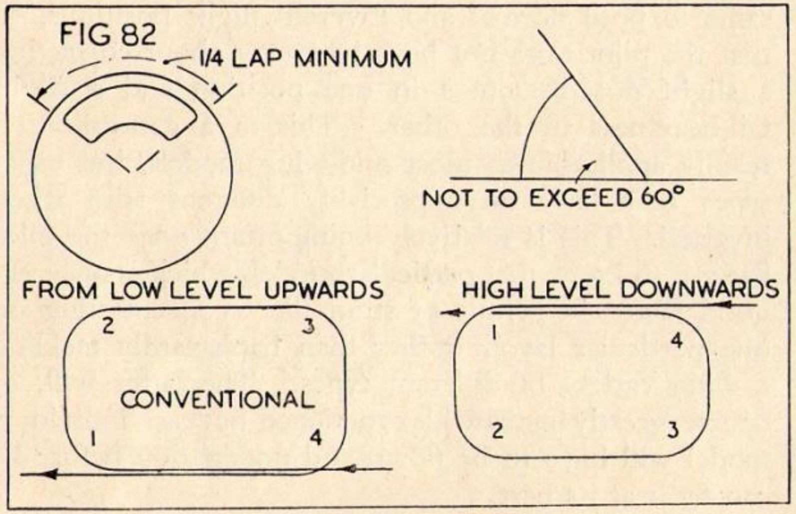
For all manoeuvres from the inverted flight position the same technique is adopted as for normal flight, with the difference that the control movements are exactly reversed. Since these are summarised in the Stunt Charts given in Chapter VIII, it is unnecessary to repeat them here. We can, however, mention one or two of the more outstanding which have not, as yet, been fully treated.

The square loop has been left to this chapter on inverted flying since it can only be performed smoothly after learning inverted flying. As Fig. 82 shows, the square loop is nothing more than a normal loop, modified so that the flight pattern is in the form of a square with

only the corners rounded off. Just how far the corners can be rounded off is very much a matter of the capabilities of the design. Some models will loop in a very small radius, others will need very much more space.

The square loop can be done upwards or downwards, from normal or inverted flight positions, four variations in all. Obviously the simplest method is upwards from normal low level flight. Here no especial difficulties are present, the only point to bear in mind being that at the fourth corner the model will have picked up speed in the dive and the radius of this turn will tend to be greater than that of the others. The second corner will tend to have the smallest radius and so to get as uniform a flight pattern as possible it may be necessary deliberately to round off this corner to conform to the radius of the others.

From normal level flight downwards, the second corner will be the most dangerous after the model has picked up speed.



Performed from inverted flight the same remarks apply, except that the flight pattern is now laterally inverted, since the model is flying the other way round. That is, instead of flying from right to left on the original diagrams, the direction of flight is now left to right. Control response is exactly opposite to normal flight.

The horizontal part of square loops should be at least one-quarter of a lap. This is usually specified as a minimum in contest rules. Some rules may give one half a lap as a minimum, so practise both. The most common error is in coming off the top of a square loop at a tangent so that the top line is wavy until the pilot has found the correct height at which to fly. A square loop downwards, of course, leaves very little room for departing from the correct flight pattern and in trying to avoid flying right into the ground the usual error is to overcorrect the second turn and produce a convex curve for the bottom line instead of a perfectly straight-flight path.

A good stunt model trims as nearly as possible the same in both normal and inverted flight positions, so that the pilot does not have to worry about correcting a slight nose-heaviness in one position and a slight tail-heaviness in the other. This is a generalisation readily applicable to most mid-wing models, but other types may have an appreciably different trim when inverted. This is relatively unimportant once the pilot has got to know that particular model, which is one very good factor in favour of stunt fliers concentrating on one particular layout rather than haphazardly tackling a wide variety of different types. The latter will, of course, greatly increase his experience, but each individual model will have to be flown and understood before he can fly it at its best.

Again contest and exhibition flying varies the technique The spectators much prefer to see a model which is obviously flying inverted, i.e., with a fixed undercarriage, and extreme low level inverted flying is probably more thrilling to them than some of the more advanced manoeuvres from the inverted position. A contest pilot, on the other hand, would never normally fly as close to the ground as possible when inverted as the slightest miscalculation on his part may lead to a crash and loss of points. Low-level flying for spectator value and exhibition work, high-level flying for safety and competition work.

APPENDIX

DESIGN DATA

DESIGN LAYOUT DATA

General Arrangement Drawings

DATA TABLES

NOTE.—In the following tables, suitable blank spaces are left so that further new data can be added by the reader as and when available. The figures already given in the Tables are representative of current practice up to the end of 1948.

TABLE A

DESIGN LAYOUT DATA

(*pages* 176-181)

Model	Designer	Span (in.)	Chord (in.)	Aspect Ratio	Wing Section Type	Wing Section Thickness	Wing Position	Wing Area (Sw)
Beelzebub ...	C. Lee	20	4¼	5	Symm.	% 17.5	Low	82
Vandiver ...	J. R. Vanderbeek	26	4¾	5.6	Symm.	10	Mid	120
Prentice	R. Prentice ...							
Ginger Snap ...	J. Bayha	32	6	5	Symm.	17½	Mid	185
Playboy "30" ...	R. H. Warring ..	30	5	6	Symm.	10	Mid	145
Stuntmaster ...	W. A. Dean ...	30	5¼ Av	6	Symm.	12.5	Mid	150
Mills Bomb ...	M. Booth							
Glo-Bug ...	C. Goldberg ...	27½	4½	6	Thin Clark Y	7.5	Mid	125
Kan-Doo ...	P. Cock	29	7	4.15	Symm.	12.5	High	200
Barge	M. Booth ...							
Magnette ...	H. J. Nicholls ...	26	6 Av	4.5	Symm.	10	Mid	156
Trainee	C. Goldberg ...	30	4½ Av	7	Thin Clark Y	7.5	Low	130
Rookie	R. D. Lidgard ...	35½	5½	6.5	Thin Clark Y	7.5	Mid	185
Testor PC-1 ...					Thin Clark Y	7.5	Mid	
Fireball	J. Walker ...	36	Elliptic	6	Symm.	12.5	Mid	190
De Bolt Bipe ...	H. de Bolt ...	23	2 x 5		Thin Clark Y	10	Biplane	220
Super Bipe ...	H. de Bolt ...	28	6&5		Symm.	12.5	Biplane	278
Dronette ...	L. Shulman ...	35½	6	6	Symm.	9	High-mid	206
Dilly		39	6½	6	Symm.	12	Low	230
Stunt Ace ...		40	7	6	Symm.	10	Mid	270
Cyclone		36	6½	6	Clark Y	12	Low	220

Total Tail Area (St) sq. in.	Total Tail Area (St) %Sw	Elevator Area sq. in.	Elevator Area %St	Elevator Range Up	Elevator Range Down	Moment* Arm (in.)	Motor	Propeller Dia.	Propeller Pitch	Model
17	20.5	7	41			4	Class A American	8	8	Beelzebub
37	30	18	49	30	30	6	Frog 160	8	5	Vandiver
										Prentice
44	29	27	62	30	30	11	Class A American	8	6	Ginger Snap
40	27½	20	50	45	45	8	E.D. Elfin Arden	8-9	6	Playboy "30"
40	27	18	45	45	45	7½	Mills	8	6	Stuntmaster
										Mills Bomb
0	0		100				Class A American			Glo-Bug
50	25	30	60			6	E.D. Comp. Special			Kan Doo
										Barge
50	33	19	38			7	E.D. Comp. Special			Magnette
							Class B American			Trainee
41	22	16	37½	25	15	11½	Class B American			Rookie
							Class B American			Testor PC-1
42	22½	15	35	30	30	10	Class B American			Fireball
46	21	18	40	45	30	6	Class B American			De Bolt Bipe
64	23	31	48	45	45	2½	0.30-0.60 cu. in.			Super Bipe
60	29	24	40			12	Drone	10	10	Dronette
							0.30-0.45 cu. in.			Dilly
68	25	34	50			12	Class B American			Stunt Ace
65	34	75	37.5	35	15	11	Ohlsson "60"	11	8	Cyclone

* Measured from trailing edge of wing to leading edge of tailplane.

Model	Designer	Span (in.)	Chord (in.)	Aspect Ratio	Wing Section		Wing Position	Wing Area (Sw)
					Type	Thickness		
						%		
Lil Zilch	G. Saftig	34	6¾	4·6	Symm.	15	Low	252
Super Cinch ...		36	7	5.2	Symm.		High	250
Hot Rock ...	R. Tucker ...	38	7	5.5	Symm.	14	Low-mid	261
Go-Devil Jnr. ...	R. Palmer ...	40	8	5·1	N.A.C.A. 0018	18	Low	315
Madman Jnr. ...	J. C. Yates ...				N.A.C.A. 0018	18	Low	
Tuckette ...	R. Tucker ...	38	7	5.4	Symm.	12½	Mid	270
Secret Weapon	L. Shulman ...				Symm.	12.5	Mid	
Barnstormer ...	E. Buxton ...	33½	8	4.5	Symm.	10	High	264
Sidewinder ...	R. H. Warring ...	40	7	6	Symm.	15	Mid	270
Teft's Terror ...	R. Teft	40	8	5	Symm.	12½	High-Mid	310
Sky Box		42/38	7	5-6	Symm.		High	294/266
Magician	W. P. Babcock ...	40	8	5	Symm.	15	Low	316
Boxcar	D. Allan	39½	9	4.2	Symm.	15	Mid	336
Boxcar Chief ...		48	8	6	Symm.		High	384
Akrobat		48	8½	6	Symm.	12½	Mid	400
Upstart	C. McCullough ...	49	8½ AV	6	Symm.	12½	Mid	390
Playboy "50" ...	R. H. Warring ...	50	8½	6.5	Symm.	12½	Mid	410
Slagle "46" ...	D. Slagle	48	9	5.5	Symm.	14	Mid	415
Green Dragon ...	J. C. Yates ...	50	9½	6	Symm.	N.A.C.A. 99	Low	470
Madman	J. C. Yates ...	49	8½ AV	6.2	N.A.C.A. 0013	18	Low	390
Go-Devil... ...	R. Palmer ...	53	11	4.9	N.A.C.A. 0018	18	Low	575
Super Zilch ...	G. Saftig	54	7	7.5	Symm.	14	Low	500

Total Tail Area (St)		Elevator Area		Elevator Range		Moment* Arm (in.)	Motor	Propeller		Model
sq. in.	%Sw	sq. in.	%St	Up	Down			Dia.	Pitch	
				30	30	9	Class B American			Lil Zilch
62.5	25	31.5	50	45	45	12	Class B American			Super Cinch
65	25	36	55	45	45	10	Drone	10	10	Hot Rock
76	24	34	45	30	30	8	Class B			Go-Devil Jnr.
				30	30		Class B			Madman Jnr.
							0.23-0.45 cu. in.			Tuckette
							Drone			Secret Weapon
55	21	25	45	45	45	11¾	Super Tigre			Barnstormer
70	26	40	57	45	45	10	Ohlsson "60"	12	6	Sidewinder
72	23	32	45			16	Class C American			Teft's Terrier
74	25-28	30		45	45	12	Class B/C American			Sky Box
58	13	19	33	30	30	8½	Class B American			Magician
80	24	45	56	45	30	10	Super-Cyclone			Boxcar
96	25	48	50	45	45		Class C American			Boxcar Chief
120	30	60	50	40	40	10	Class C American			Akrobat
115	30	45	40			9½	Large Class C	12	8	Upstart
88	21.5	40	45	40	40	10	Ohlsson "60"	12	6	Playboy "50"
96	23	45	47	40	30	8	Super-Cyclone	12		Slagle "46"
97.5	21	45	45	40	40	8	Orwick "69"	11½	9	Green Dragon
80	20.5	40	50	30	30	9	Orwick "64"	12	9	Madman
120	21	52	42	30	30	8½	Orwick "64"	11½	9	Go-Devil
75	15	30	40	30	30	9	Super-Cyclone			Super Zilch

* Measured from trailing edge of wing to leading edge of tailplane.

Model	Designer	Span (in.)	Chord (in.)	Aspect Ratio	Wing Section		Wing Position	Wing Area (Sw)
					Type	Thickness %		

Total Tail Area (St)		Elevator Area		Elevator Range		Moment* Arm	Motor	Propeller		Model
sq. in.	%Sw	sq. in.	%St	Up	Down	(in.)		Dia.	Pitch	

* Measured from trailing edge of wing to leading edge of tailplane.

TABLE B

C.G. Position Data

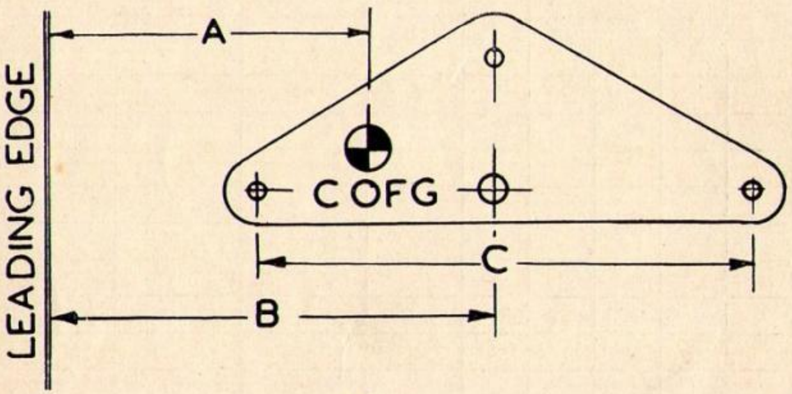


FIG. A

Model	*Chord in.*	*A in.*	*B in.*	*C in.*	*Remarks*
Vandiver	4$\frac{3}{4}$	0-$\frac{1}{2}$	2$\frac{7}{16}$	2$\frac{1}{2}$	
Pee Wee Zilch ...	5	1	1$\frac{3}{4}$	2	
Playboy	5	1	2	2	Well forward.
Stuntmaster ...	5$\frac{1}{4}$ Av		2$\frac{1}{2}$	2$\frac{1}{2}$	
Mills Bomb					
Kan Doo	7	2	3$\frac{1}{2}$	2	
Fireball		1$\frac{1}{8}$-1$\frac{3}{4}$	3$\frac{3}{4}$	3$\frac{7}{8}$	
Dronette	6	$\frac{1}{2}$	3	3	C.G. well forward.
Lil Zilch	6$\frac{3}{4}$	1$\frac{3}{4}$	2$\frac{1}{16}$	1$\frac{1}{2}$	Lines raked back 2°
Hot Rock	7	$\frac{1}{2}$-1	2	3	
Go-Devil Jnr. ...	8	1$\frac{7}{8}$	2$\frac{3}{4}$	3$\frac{1}{2}$	Flaps used.
Barnstormer ...	8	2$\frac{1}{4}$	3$\frac{1}{4}$	2	
Sidewinder ...	7	$\frac{3}{4}$	2$\frac{1}{8}$	3	
Magician	8	2$\frac{1}{2}$	3$\frac{3}{4}$	2	C.G. well aft.
Boxcar (Allan) ...	9	1$\frac{1}{2}$	3$\frac{1}{4}$	2$\frac{3}{4}$	
Playboy " 50 " ...	8$\frac{1}{2}$	2	4	3	
Madman	8$\frac{1}{2}$	2$\frac{3}{8}$	3$\frac{1}{2}$	3$\frac{1}{2}$	
Go-Devil	11	2$\frac{3}{4}$	3$\frac{1}{2}$	3$\frac{1}{2}$	Asymmetric wing.
Super Zilch ...	7	2$\frac{3}{8}$	3$\frac{1}{2}$	3$\frac{1}{2}$	

TABLE C

Control Plate Data

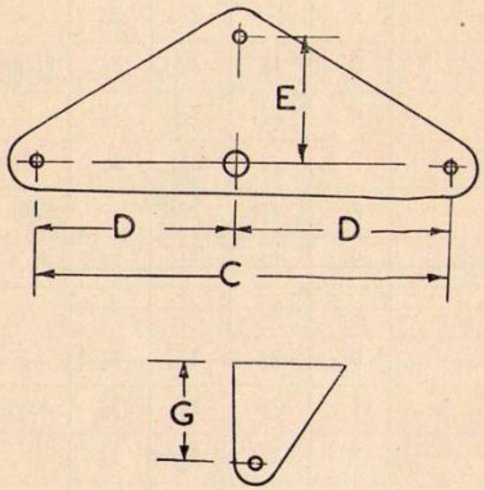


FIG. B

Model	*C in.*	*D in.*	*E in.*	*G in.*	*Material*
Vandiver	$2\frac{1}{2}$	$1\frac{1}{4}$	$\frac{9}{16}$	$\frac{1}{2}$	3/32 Ply.
Playboy	2	1	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{16}$ Aluminium.
Stuntmaster ...	$2\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{16}$ Aluminium
Kan Doo	2	1	1	$\frac{1}{2}$	$\frac{1}{16}$ Aluminium
Fireball	$3\frac{7}{8}$	$1\frac{15}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	Fibre.
Dronette	3	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{16}$ Aluminium.
Lil Zilch	3	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{1}{16}$ Dural.
Hot Rock	3	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{16}$ Dural.
Go-Devil Jnr. ...	$3\frac{1}{2}$	$1\frac{3}{4}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{1}{16}$ Dural.
Barnstormer ...	2	1	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{16}$ Dural.
Sidewinder ...	3	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{7}{16}$	$\frac{1}{16}$ Dural.
Magician	2	1	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{16}$ Dural.
Boxcar	$2\frac{3}{4}$	$1\frac{3}{8}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{16}$ Dural.
Playboy "50" ...	3	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{16}$ Dural.
Slagle "46" ...	$2\frac{1}{8}$	$1\frac{1}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	Dural.
Madman	$3\frac{1}{2}$	$1\frac{3}{4}$	$\frac{9}{16}$	$\frac{9}{16}$	Dural.
Go-Devil	$3\frac{1}{2}$	$1\frac{3}{4}$	19/32	$\frac{9}{16}$	Dural.
Super Zilch ...	3	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	Dural.