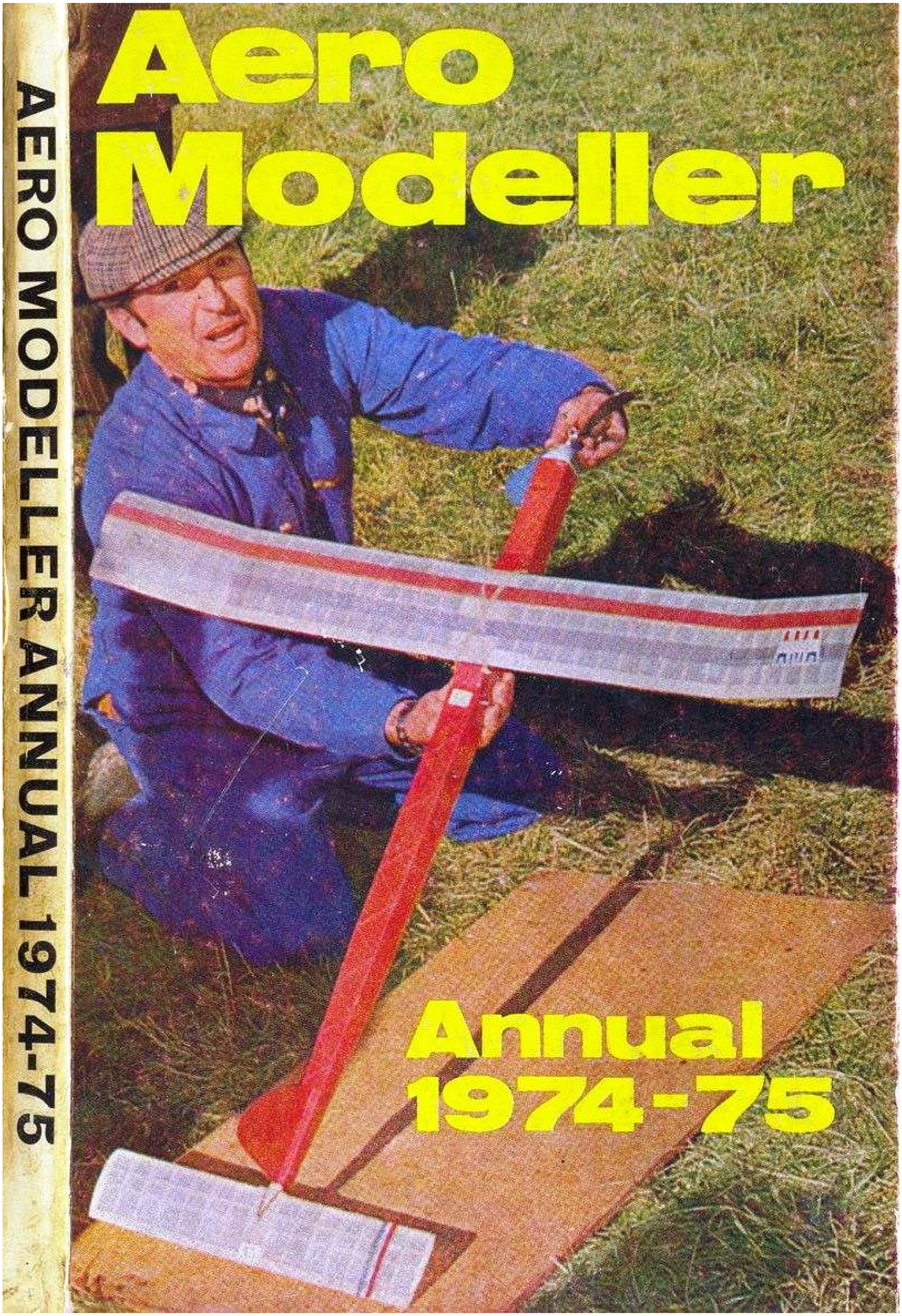
AERO MODELLER ANNUAL 1974-75
Aero
Modeller
Annual
1974-75

AEROMODELLER ANNUAL 1974-75

A review of the year's aeromodelling throughout the world in theory and practice: together with useful data, and authoritative articles, produced by staff and contributors of the *AEROMODELLER*

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INTRODUCTION

1974 will probably go into the annals of aeromodelling history as one of the most memorable. Kind weather favoured all the major rallies, especially the record breaking British National Championships at R.A.F. Little Rissington and the hobby engaged itself in a boom that still astounds the trade for its incredible rise in turnover.

It was also a year of achievement. First crossing of the Channel, from Ashford, Kent to Ambleteuse near Boulogne was a British planned, German equipped and flown International effort when on July 17th, Dieter Ziegler piloted his Bell 212 for 67 tense minutes across the heaving sea. Fate seemed to charm him, for who would expect a Northerly wind in July? And who would have believed, even two years back, that a model helicopter could lift more than its own weight in fuel and fly for 1¾ hours!

The World Championships in the U.S.A. were an experience of mixed feelings. Frustrated efforts to organise a European co-operative charter cost the A.M.A. a large deposit. Keen nations found their way to the U.S.A., among them a 49 strong party from the U.K., and amid the warmth and generosity of American modellers, they found themselves faced with an undermanned, underplanned week long AerOlympics that threatened to be disastrous. Spartan accommodation, long distances to walk between centres of activity and high temperatures gave Lakehurst, New Jersey a reputation that will not be envied. Yet the great American gift of on the spot improvisation, aided by initiative of the competitors, made this multiple event meeting a success. Even a mini-hurricane which drenched everyone, including those inside huge Hangar Number 5 where the Indoor Championships were taking place, failed to diminish the enthusiasm of the participants. But the password was clear—"When can we go back to Cranfield and Cardington?" was on many lips. Congrats to Bob Wischer (U.S.) the R/C Scale Champ, to Valery Kramarenko (U.S.S.R.), the C/L Scale Champ and to the new Indoor World Champ, Ryszard Czechowski of Poland.

The AerOlympics included two International contests. Pylon racing, a highly competitive event where speed is paramount, was won for the third time by the team of Bob Violett and Cliff Telford, who hold the Sopwith Trophy for yet another year. They were given a chasing by a strong British contingent, bold in spirit, but suffering sadly in the dreadful problems of 27 mc/s and its interference. Thermal Soaring to the provisional F.A.I. triple task rules was similarly well supported, and deservedly won by South African, Mike Malherbe, a fine chip of the old block who went to learn, and came away as the tutor! Lakehurst was also the site for the S.A.M. Nats, meaning the old timers and pre 1938 "Antiques". This introduced a fascinating class to us in the form of radio assisted free flight with 10 minute maximums, spot landings and piloting from a deck chair! Just the thing for old editors!

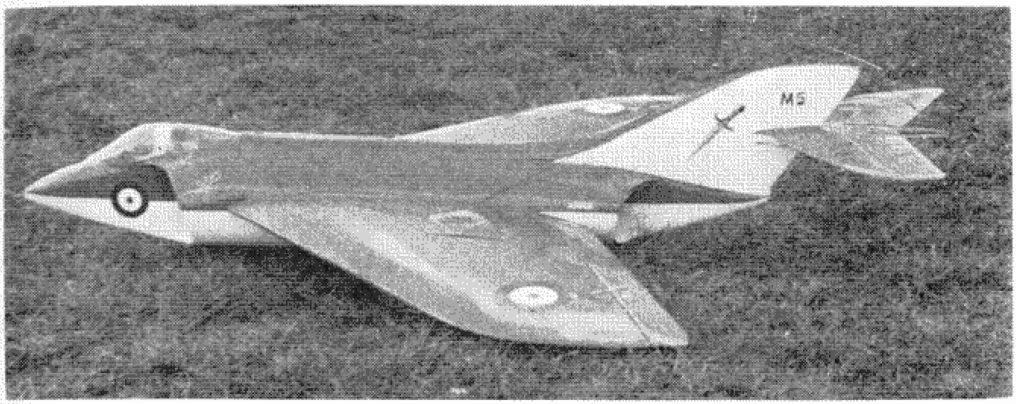
Also in July, the World Champs for Control Line was held in Czechoslovakia at the specially prepared circles of Hradec Králové. In spite of political exclusions, twenty-two nations supported the contests with almost 300 participants and many new, high standards were established. It saw the Soviet supremacy of team race efficiency challenged by the elementary (and old) device of line "grouping". To gain up to 10 m.p.h. simply by joining control lines together is a technical leap-frog, that gave British team racers, Heaton and Ross the distinct honour of making fastest heat time. Onufrienko and Shapovalov won the individual title, top nation in team race for 1974/5 was U.S.S.R. U.S.A. remains at the pinnacle of control line stunt, with Bob Gieseke the leader and in speed, the Italians were so fast at speeds approaching 300 Km/h that they could scarcely keep up with their models around the pylon.

Of engines, the world simply hasn't enough and 1974 found every manufacturer heavily back ordered. In a trip to Japan, we were able to visit factories where production is up to 700 per day, and almost half are sold to the Japanese domestic market. As leading nation in radio control aerobatics, and prominent in manufacture of model equipment, Japan presents a fascinating picture of intense activity. Constantly looking forward, the designers of Japanese engines, kits and radio control are facing up to escalating material costs with realism and have a constant flow of new products among them new electric motors for free flight and radio control.

Free flight progress is reflected in some of the designs reproduced in this Annual. Among the three reigning individual champions from 1973 are a Russian Glider, and an East German Wakefield. Their skills are well known, but the 1974 Soviet International in East Germany saw North Koreans almost sweep the board, a foretaste for exciting 1975!

On the Cover

Colourful French Coupe d'Hiver specialist R. Carrigou in typical take-off pose at the annual M.R.A. International 1974



First flown in March 1974, the author's 34 inch "Stiletto" is a 4 lb design powered by K & B 40 driving a 5 inch diameter fan.

PRACTICAL DUCTED FANS

Marcus Norman carries on the tradition of his famous father with simulated jet flight

WITH the advent of the jet engine and subsequent practical use to which it was put as a power plant for aeroplanes, the piston-engine prop-driven aircraft has become obsolete for fast transport, and new shapes and forms fill the ever-decreasing air space of the world. The history of the jet engine is known to most people and its advantages and disadvantages have been apparent now for some forty years.

In the same way the introduction of the miniature spark-ignition engine opened up new fields of design and form to aeromodellers. When the model diesel engine was first introduced, a wider field of model aviation was again open to aeromodellers. Now, with radio control and glow plug engines, we have models which perform aerobatics as well as, if not better than, their real counterparts. Scale models have become exact replicas of real machines incorporating everything down to the smallest rivet detail (or even the wart on the pilot's nose!).

Thus when we come to model jet engines and jet aeroplanes, the comparative evolution of model aeroplanes with their real counterparts comes to a grinding halt. There have, of course, been such power plants typified by the Dynajet reaction jet, fired with white spirit and producing immense thrust for a short space of time. (These have become impractical for either free flight or radio-controlled models. They are used on control line models, but by and large they are both over-noisy and over-hot for model use by the average aeromodeller.) Jetex solid pellet fuelled rocket motors were ideal for small free flight models, but certainly not practical for a radio-controlled model.

There is, of course, the possibility of building a miniature jet turbine engine but, again, a high degree of technical know-how would be necessary not only to make it but also to maintain it in operations on the flying-fields.

This leaves us with the long accepted ducted fan method of propulsion. At this point the reader is firmly instructed not to put the article down and say

"No-go for the average modeller, something for the experts—power is marginal, etc., etc.", but to keep reading on because afterwards some may say "*Not so difficult or freakish as I first thought*".

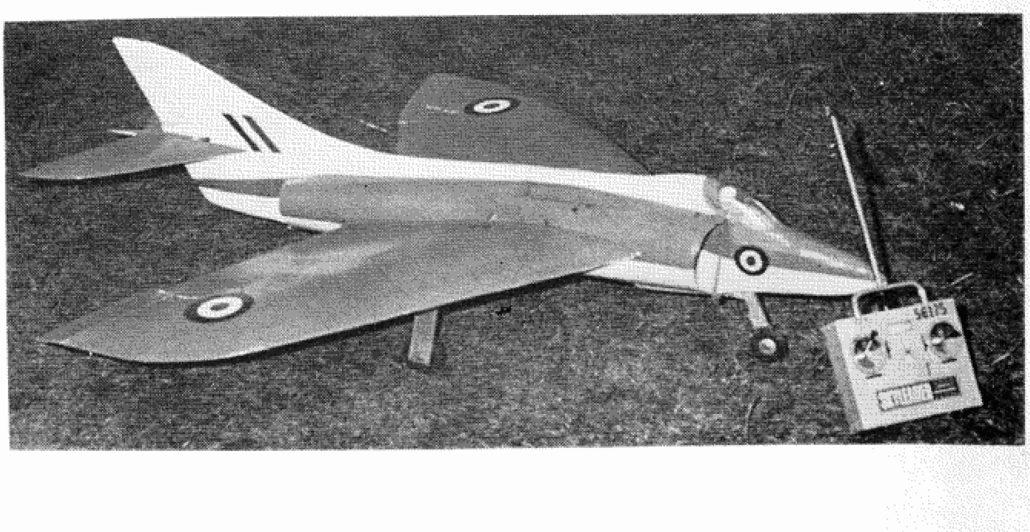
It is not clear who actually invented the ducted fan system, but there are records of the Coanda ducted fan powered aeroplane built in 1910 and the famous Caproni-Campini CC2 aeroplane in 1941 driven by this method of propulsion. The engine (piston) was amidships, driving a turbine compressor in a duct. The machine flew well at speeds of above 200 mph.

In the field of model aviation a number of names spring to mind when Ducted Fan designs are mentioned. Phil Smith, designer of Veron, who produced such well-known kits as the Lavochkin and the Fairey Delta II. Another experimenter was Mr. Newbold who produced a Ducted Fan "Vampire" for control line flying which was successful. In America Mr. Schnitz produced a number of articles on the subject, John Coatsworth, who experimented with amazingly good results on the Centrifugal type of impeller, and last but by no means least (may I be permitted to say it), perhaps the most successful of all, P. E. Norman.

P. E. Norman and Phil Smith favoured the axial-mounted fan which for all practical purposes seems to be the most efficient and most effectively simplest to build and put into operation; and it is upon P. E. Norman's successful ideas that all my DF models both free flight and radio controlled have been based.

It is probably true to say that "P.E." was one of the first aeromodellers to fly a successful DF model and scale type in the country. His first machine being a model of the then new Soviet fighter the Mig. 15, the year being 1950 and the place the Wye Downs near Ashford, Kent. Like all revolutionary ideas, it is from this original form of model that he evolved successive and more successful DF models, until on his death in June 1964 six of his machines carried single channel rudder-only radio control. Other modellers on Epsom Downs said, "*How clever, the man's an expert, etc., etc.*". All this is of course true, but one doesn't have to be a genius to build and fly this sort of model especially now that the ground work has been done.

I really did not know much about the actual theory of DF design; or even building and flying them. I had obviously watched "P.E." build his and I actually handled a single channel one in flight, but as far as knowing why the machine stayed in the a ir and how and why it travelled forward, climbed and dived, etc., pushed along merely by a stream of air, I was as much in the dark as anyone else. In fact here I will make a confession that, up until the time of "P.E.'s"



Opposite: the "Epee", Marcus Norman's very successful 40 powered model which has been flying since November 1971, see plans on pages 20–21. At right: Marcus and the "Lightning" as mentioned below.

death, I had only built a few powered models of the conventional type; and the usual assortment of small scale rubber types, catapult models, etc. Some flew well, others didn't fly at all. The point I am trying to make is that at that time I was not an experienced modeller in any sense of the word, and yet I managed to build and fly a successful DF model, after a couple of marginal successes; and since then I have built and flown multi DF designs in excess of 5 lb. weight.

"P.E." had written a number of articles on DF designs, as had a few other people and all these I read thoroughly. The articles that were technical and which involved mathematical formulae meant nothing to me at all, and the others did not give much away as to the practical application of a DF power unit. Consequently, the only thing I could do was to build a DF for myself. Having seen some of the Veron and "P.E.'s" DF designs fly, I felt that "P.E.'s" performances were probably of a better calibre; and so I felt that his fan, duct and general layouts were of a better nature. However, being a hot-headed (I think) young man and of course knowing much more than anyone else, I built a machine incorporating *none* of these sensible and tried features. Quite naturally the result was not spectacular. This story was repeated roughly along the same lines; and then it occurred to me that perhaps "P.E." did know more about this subject than I did. My next model was a free flight model of the *English Electric* "*Lightning*". Before "P.E." died, he had talked about the possibility of building and flying a single channel "*Lightning*" incorporating his own design features, and I thought, if he had this sort of aeroplane in mind, then he would have been pretty sure that it would be successful. So, using his method of constructing the fuselage in $\frac{1}{32}$-in. ply and incorporating his duct, intake, fan and efflux sizes, I built the model (free flight). I took it to Epsom Downs and "Hey Presto" the model flew beautifully. The moral of this little saga being, if someone has spent years striving for perfection in something and in fact has gained a good deal of success, then don't ignore the methods incorporated, but use them, and then seek to improve upon these ideas where possible. Don't run before you can walk.

Now for the "nitty gritty" (*no* don't close the article, the prologue is over, the action begins).

Practical Theory of Ducted Fan Design

The basic function of the DF unit is to suck air in at one end of the duct, increase the velocity at which it is travelling by means of a fan and then expel the speeded up mass of air through the rear end of the said duct, thus producing an opposing force upon the duct and therefore propelling it forward by means of the "jet stream".

Therefore a DF unit must consist of:

(A) A duct (or pipe) intake.
(B) A fan (or impeller).
(C) A motor of some form to drive the fan.
(D) A duct efflux (rear end hole).

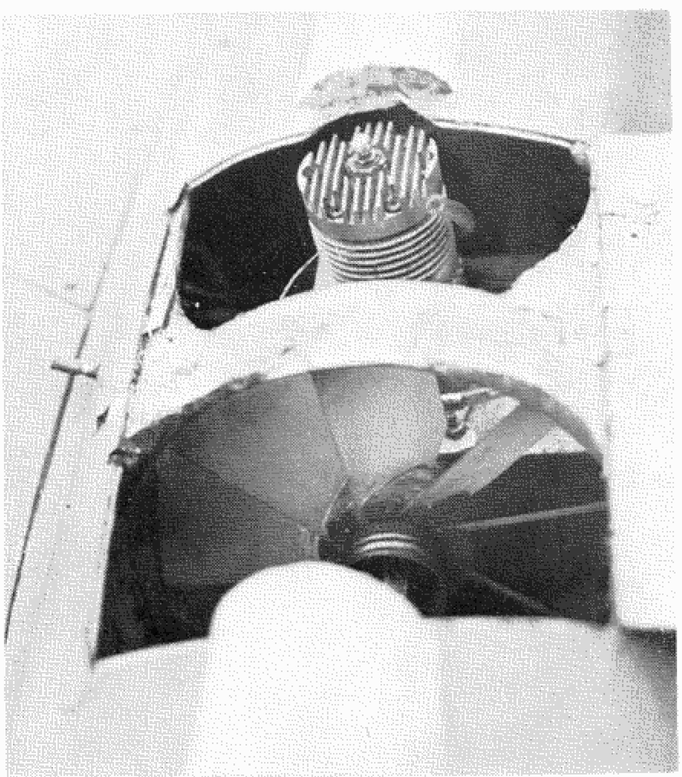
Now let me explain in a simple and practical way each of these items in turn.

(A) The Duct

Intakes

The Ducted Fan unit relies on the volume of air passing through the duct; rather than compression of that air before expulsion through the efflux. (In a real jet engine, compression of air is essential before ignition with the kerosene and subsequent expulsion of gases at a high velocity to provide propulsive thrust.) From this it can be at once appreciated that the "ducted fan" is *not* a jet engine in the sense of the word as we know it.

"P.E." discovered within the first couple of years of his experiments with fans that this paragraph was in fact true, his conclusion being drawn from the field of trial and error rather than mathematical or technical calculation. With regards to the intake areas, it is apparent that a good volume of air is required to



Typical Norman motor and fan installation at left, seen through opening hatch for access to starting via pull-cord on bottle top "spinner". Opposite: the "Epee" intakes are of generous size.

enter the duct, and this one can notice on looking at "P.E.'s" early Mig 15s and observing that there are numerous holes cut around the front end of the model to increase the volume of air passing into the duct. On his later models of the same type, we see a "cheating" in the size of the scale type intake, and as a result there is then no need for extra intake holes to be cut.

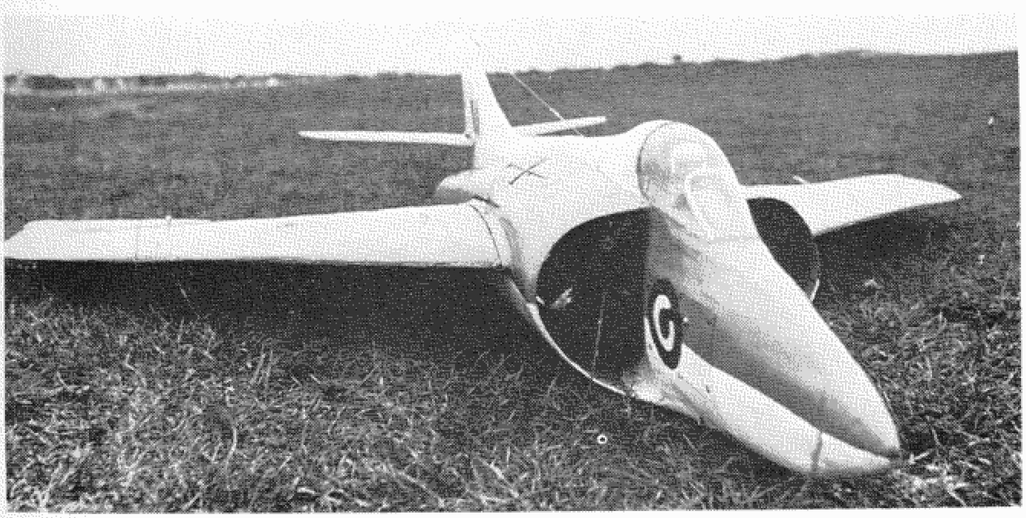
Taking a measurement of the intakes on his subsequently more successful models we find that the total intake area is 80–95% of the circular area of the fan (bear in mind, however, that at this period in time diesel engines were the main motive force for driving the fan). A conclusion to this paragraph can therefore be stated as follows: *The intake area of a ducted fan unit should be as near to the circular area of the fan as is possible; and that the said area should not drop below 80%.*

(B) Fan Size and Shape and Type

Once again on "P.E.'s" early Mig type DF design, it can be observed that for a 2·5 Elfin diesel engine the diameter of the fan was approximately 4–4¼ in. Made of twisted aluminium, this type of construction soon being discarded as the blades had a habit of crystallizing through vibration and then shearing off, causing disastrous results. For example, there are two early models which I have in my possession that are constructed of balsa sheet and ply respectively and both have a large hole adjacent to the engine mounting and fan ring. It was a direct result of this danger that a built-up fan was developed (more construction detail later). The diameter of these later fans was still 4–4¼ in. for 2·5 diesel.

(1) *Blade Nos., Shape, etc.*

I have in my possession a considerable assortment of fans of various shapes, sizes, and a number of blades. They vary from three blades to twenty-four blades (the latter having centre bosses ranging from a normal propeller size to a very large diameter as in real jet engine turbine bosses). However, the fans that appear to have been the most efficient were six blades for engines up to 2 c.c., and eight blades for engines from 2 c.c. upwards. I have chosen to use eight blades on engines up to the K&B Series 71 pylon racing engine type, although of course my fans are now made of more durable materials than the fibre type as used by "P.E.". My fan blades are also of a different and modified shape to the early ones



used by "P.E.". This type would appear to be still the most efficient, and indeed my results have been (I believe) very good indeed.

(2) *Placing of the Fan in the Duct*

It is essential when placing the fan in the duct, that it has a close proximity at the blade tips to the surrounding fan ring, thus reducing air spillage over the tips and therefore increasing efficiency.

(3) *Fan Sizes*

It would appear that fan sizes are mainly (as would be expected) governed by the size of motor used; but not in the same ratio as with the ordinary propeller to a given engine. I have set out two tables, one containing the sizes of fans used for particular engines by "P.E." and the second containing sizes of fans to particular engines that I have evolved, all my engines being glow motors as opposed to diesel engines.

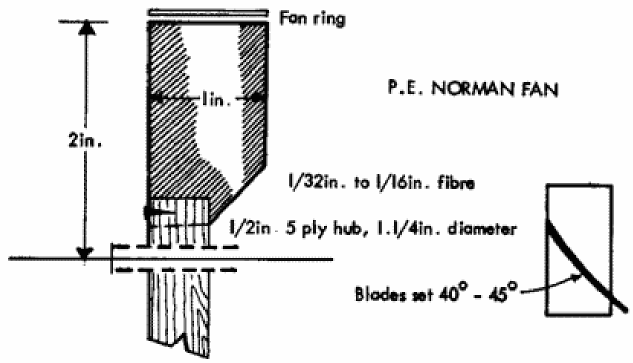
TABLE 1 P. E. NORMAN FANS

Engine c.c.	*Blade Nos.*	*Fan Diam.*
(D) 1	6	3–3½"
(D) 1·5	6–8	3½–3¾"
(D) 2	8	3¾–4"
(D) 2·5	8	4–4¼"
(D) 3	8	4¼–4½"
(G) 3·5	8	4½–4¾"
(G) ·29	8	4¾–5"
(G) ·35	8	5–5¾"
D =	Diesel Engine	
G =	Glow plug Engine	

TABLE 2 M. NORMAN FANS

Engine cu. ins.	*Blade Nos.*	*Fan Diam.*
(G) ·15	6–8	3¼–3½"
(G) ·19	8	3½–4"
(G) ·20	8	4–4¼"
(G) ·35	8	4¼–4½"
(G) ·40	8	4½–5"
G =	Glow plug Engine	

It can be seen from these tables that I favour a slightly smaller fan for a given size of engine, in comparison with "P.E.'s". There are two main reasons for this, one is that a diesel engine is slower revving (or rather used to be) and therefore its peak power is at a lower r.p.m. than with a glow motor which is capable of higher r.p.m., and which more often than not gives its peak performance at higher r.p.m. Consequently with a diesel motor a greater blade area is required to give effective power and therefore "P.E.'s" fans have diameters slightly larger than mine for the same given power. The second reason for my fan being slightly smaller is that the material available to "P.E." for the construction of his fans (i.e. fibre) for blades, were of a lower strength than the new materials (i.e. "Permaglass" and "Polycarbonate") which I now use for blade construction in my fans. I also use a slightly smaller diameter hub per given fan size than "P.E." and I am once again able to do this through the use of the two blade materials mentioned above.



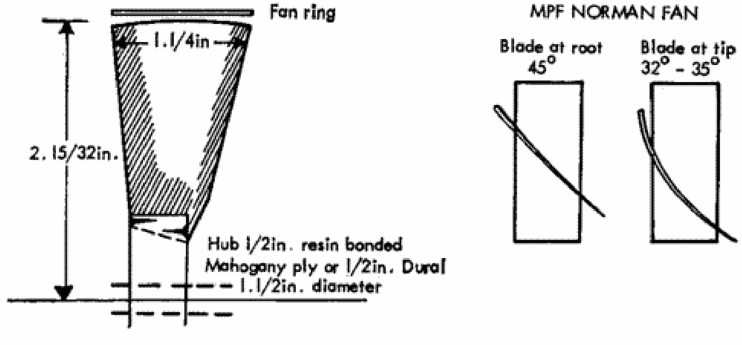
While I am on the subject, the Permaglass is $\frac{1}{16}$ in. thick and obtainable from Permalli Ltd., Gloucester Road, Bristol, but has to be bought in minimum quantities at £8 per time. The other material, "Polycarbonate", is $\frac{3}{32}$ in. thick and I think much better even than Permaglass, being more flexible and easier to work, it is also possible to mould it into shape, using the kitchen oven (when the wife is out!). The other big advantage is that it is easier to obtain than Permaglass. It is obtainable from Visija Laboratories, Croydon Airport, Purley, and can be bought in any size and at any amount cost wise at a time.

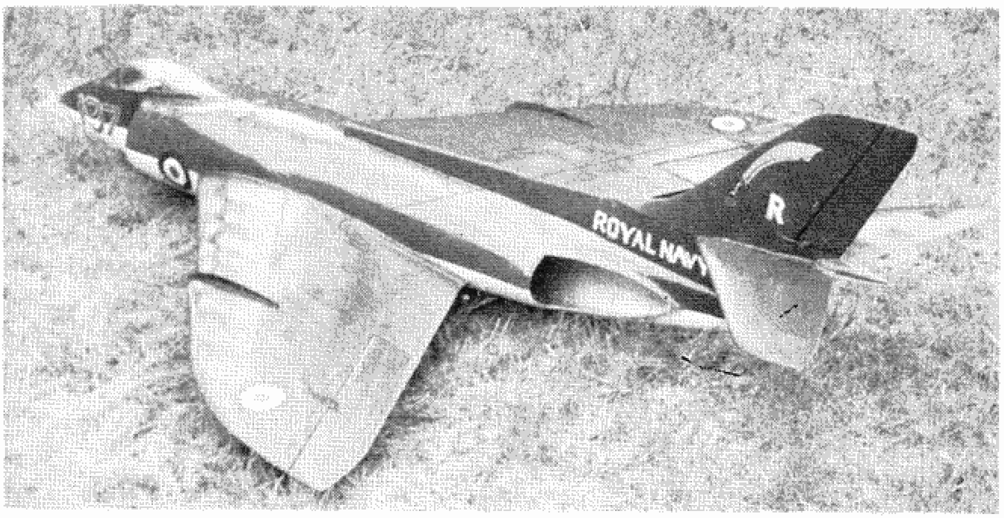
By using these types of materials, I am able to use a smaller hub and consequently a smaller fan diameter, which in turn enables the glow engine to turn over at its maximum r.p.m., thus giving maximum power. At the same time I have altered the shape of my blades from that used originally by "P.E." and now attain a very high degree of efficiency from these fans.

I have found that my fan design in conjunction with both glow and diesel motors produces a marked degree of efficiency in thrust over that of "P.E.'s". A small thrust test I did, by suspending a model from a cord and attaching a spring balance to the rear and then starting the engine, produced two startling results.

The model weighed 2½ lb. and was powered by a ·15. Using the old style fan of diameter 4⅛ in. it produced a thrust of ½ lb., using a new type fan it produced a thrust of ¾ lb. Quite a startling difference.

This test was confirmed when a friend of mine, who is also keen on D.F. models single channel and free flight, produced exactly the same result on a model of a comparable nature. One important factor seems to be to induce as much curve on the blades near the tips as is possible. The ideal fan would have its blades set at almost 90° to the hub and then have an induced curve and camber to 32–35° near the tips, to do this, however, only a fully moulded blade would be the answer, so for the present, 40–45° at the hub makes a good average and also enables fairly easy fixing.





Scimitar is a 41 inch span model, flying since June 1972. It weighs 5 lb. and is powered by an OS MAX 40P.

Conclusion to Section B

The design and the construction of a fan for any given engine is probably the most important factor in DF design, and therefore the greatest care should be taken in the construction of this item when building a model. (It usually takes me approximately six hours to build one fan, balance it and carefully shape and finish the blades. I have my hubs turned up on a lathe by a friend, which cuts out a bit of time, otherwise it would be near an eight-hour job.) The big consolation is that in the event of a crash the fan is rarely damaged.

(C) Power Plant

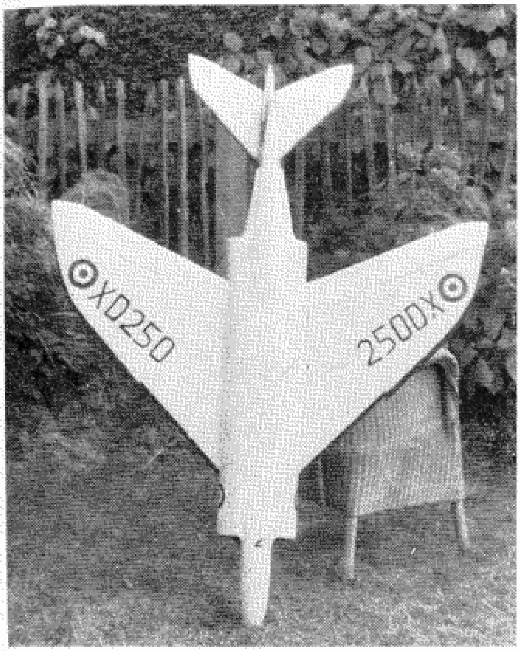
Always a big question: "*What engine should I use?*" In ducted fan design the answer is "an engine of a good power/weight ratio".

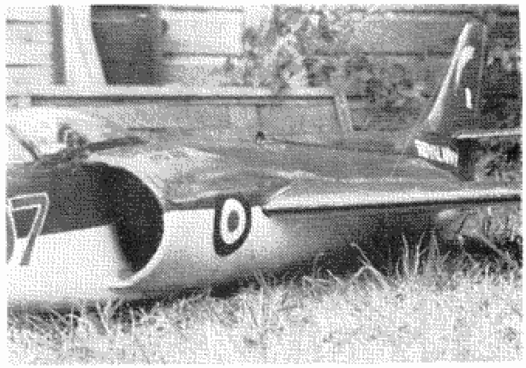
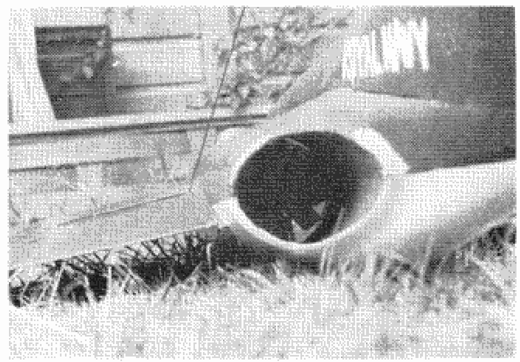
Therefore an engine that is light in weight for the power it produces and preferably capable of peak output at a high r.p.m.

I will try and explain the importance of this. In general, it is true to say that as an engine gets larger, its power weight ratio gets poorer. For example, the Cox Olympic 2·5 produces more power in comparison with its weight than say a 3·5. Fox, likewise; and probably more important to anyone building radio control ducted fans. The Max 40 develops more power for its weight of 8 oz. than does the Max 60 for its weight of approximately 14–16 oz., and when you take a K&B pylon racing engine, especially the new Schnuerle ported one which can develop up to 1·6 b.h.p. at a weight of approximately 8½–9 oz., in comparison with even a good 60 which may develop up to 2 b.h.p. but for a weight of at least 16 oz., it can be seen that as far as DFs at this present stage are concerned a good 40 is better than an equally good but heavier 60.

Weight, you will gather, is still a fairly important factor in DF design (as indeed it is, or should be, with any high performance design), but more of this later.

Another rather important factor is that one cannot just stick a huge 60 into a DF specifically designed for a 40. This is because the whole model has to be built around a particular engine, and therefore one immediately



Three views of the Scimitar illustrate the bifurcated entry and exit of the propulsion duct.

would come up against fan problems, as, obviously, if a model had been designed for a 40 one would have made the fan size approximately 5 in. diam. and therefore this would be too small for a 60, which would need approximately a 6-in. fan, thus resulting in a complete need for redesign of the model.

I am not saying that a model could not be built around a good 60 but as yet the best success I have had has been with models powered with good 40's, i.e., Max. 40, K&B 40 series 70 pylon and K&B series 71–72 pylon engine.

Conclusion to Section C

A good engine of high performance in the 40 range would seem to be the best for models of average size, i.e., up to 46-in. span, straight wings and up to 40-in. span swept wings.

(D) The Outlet or Efflux of the Duct

I stated earlier on in this article that the DF unit does not rely on the compression of the air passing through it, but rather on the volume of air emitted from the efflux; and, although this is true, it would seem that a slight decreasing of the efflux area in relation to the fan circle area increases the efficiency of the unit, and so it could be arranged that, in fact, a slight compressing of air passing through the duct is essential. "P.E." discovered that if, however, the efflux area was decreased too much, the resulting effect was to cause the fan blades to stall and therefore the amount of thrust being delivered was cut quite dramatically. (This is quite effectively illustrated when one puts one's hand over the efflux of a duct, the revs. immediately drop until finally the engine stops.) Likewise, if the efflux area is too large (i.e., the same size as the fan circle area), then the same result is observed, although to a lesser degree. In consequence to these results, therefore, it is obvious that there is some ideal "in between". "P.E." found that an efflux area of between 75% and 80% of the fan circle area produced the best results, and it is on this same basis that the efflux sizes that I used are based. It does seem that a slight reduction or enlargement above these sizes is possible nowadays, and this is probably due to the greater power that is now available from the newer glow plug engines, but 68–70% would be a minimum and 88–90% of the fan circle area would be a maximum to maintain the degree of efficiency that is needed for a unit.

Conclusion to D

It can be concluded from D that although volume of air passing through the duct is a very important factor in DF design, a slight compressing of air is also needed for maximum efficiency.

An additional question that one probably would ask, would be: "*What about the length of the actual duct?*"

I have found on my models that as long as the duct is not overlong, i.e., say over 40 in. and likewise not too short, i.e. 20 in., that the efficiency of the unit is not very much affected. The only trouble with a long duct is, of course, the longer it is the heavier it becomes. A good average length would be from, say, 24–35 in.

A Brief Summary of the Duct Unit

(1) The "intake" area should ideally be 88–100% of the fan circle area, and the two most efficient types would appear to be either "Elephant Ear" intakes as on the *Supermarine* "*Scimitar*", "*Swift*" or "*Harrier*", and they must still add up to the 88–100% required. Or "open" type intakes as on many Russian types, i.e., Mig 15, etc.

(2) The "fan" should be very carefully made and is the most important factor in the DF unit. Size is determined by power plant to be used, and with an ideal of eight blades.

(3) The engine used should be of the best power-weight ratio that is obtainable.

(4) The efflux area should ideally be 75–80% of the fan circle area. Once again it can take the form of "Elephant Ear type"—this is where the tail block is inserted in the centre of the efflux to take the fin and rudder, etc. Or of the straight through "open" hole type. In the case of the "Elephant Ear" type, the two outlets must add up to the 75–80% of the fan circle area required.

(5) The length of duct should ideally be between 24–25 in., although 20–40 in. is still possible. Apart from the weight factor in an overlong duct, in a shorter duct, the amount of down thrust required at the efflux is rather large, and here one has to be careful when putting the vanes in not to decrease the area of the efflux too much.

(6) A cone behind the engine and tank in the rear duct probably increases efficiency slightly and helps to straighten out the flow of air passing through it. I always insert a cone behind the engine and tank, and make it long enough to reach the efflux end.

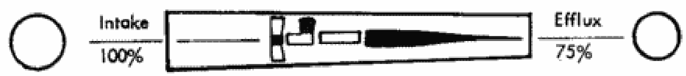
Airframe Design of DF Models

(A) Fuselage

With most fighter-type jet aircraft the fuselage is basically the duct, plus such extras as nose assembly, cockpit, spine fin and rudder. Likewise it is best to make the duct of one's model the basic (or in the case of Russian type designs) the whole fuselage.

The simplest form that this could take is obviously a straight pipe larger at the intake end and tapering down at the efflux end to the required efflux size and area, and having a circular section. (See *Fig.* 1.)

Fig I



This is of course the simplest form of fuselage to build, especially using rolled $\frac{1}{32}$-in. ply, a material which I always use for construction of my ducts, as it is relatively light and strong. On this basic duct a number of varieties of design can be constructed. (See *Fig.* 2.)

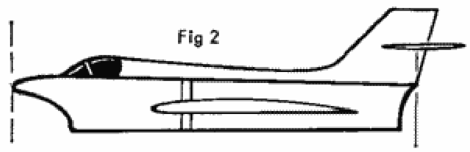


Fig 2

Fig. 2 could be delta winged with delta tail. Or swept winged with swept tail or delta winged with swept tail, or even straight winged with straight tail.

When building one's first DF design (and it is always advisable to build a small free flight one first), this basic type may be the ideal to start on. (Radio modellers note: Try a small free flight one first—that gear costs a lot of money.)

Although this fuselage is a good basic design, I personally do not find the straight stark lines aesthetically pleasing; and so bearing in mind all the factors that have gone before concerning areas, etc., one can start to "juggle" with the basic tube. (See *Figs.* 3, 4, 5.)

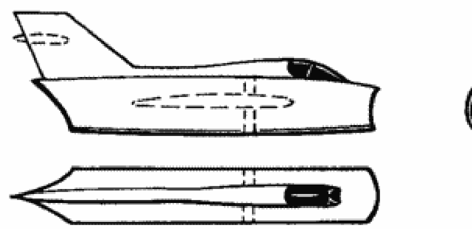


Fig 3

Note that although the nose section is slightly tapering to an apparently smaller intake area, from the top view it can be seen that the width is now very slightly wider than the fan, thus a small ovalling of section has taken place, but the intake area remains basically the same. This in turn forms a more aesthetically pleasing and in fact a truer jet-like appearance. In a similar fashion, the same can be done with the efflux.

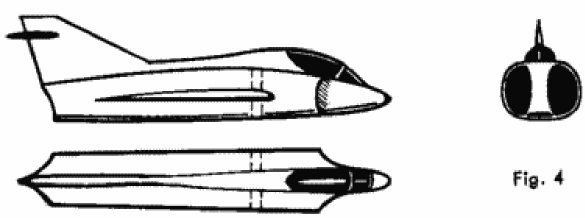
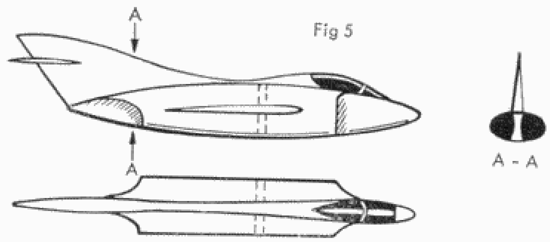


Fig. 4

Note that although we have now added a nose block in the centre of the intake, we have once again increased the width of the front end of the duct, and also at the cockpit the nose block is "waisted" quite considerably, thus making the intake area still within the 88–100% of the fan ring area required. For this design the efflux remains as it was basically in *Fig*. 3. This design would best suit delta wings and tail, or straight wings and tail.

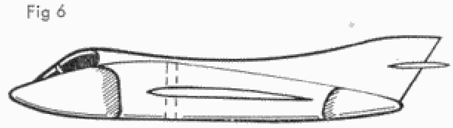
Fig 5



Note that in this design, the duct is shortened a bit more but made wider at the efflux end to facilitate the addition of the tail block: also note that the tail block is "waisted" as on the nose block in *Fig*. 4.

I think it would be agreed that the design of *Fig*. 5 is more aesthetically pleasing than either of the other two in *Figs*. 3 and 4. Of course, one can keep the bottom line of the fuselage straight, especially along the actual duct length. See *Fig*. 6. This means less shaping of the bottom shell, but in turn requires a greater longitudinal curve on the top shell.

Fig 6

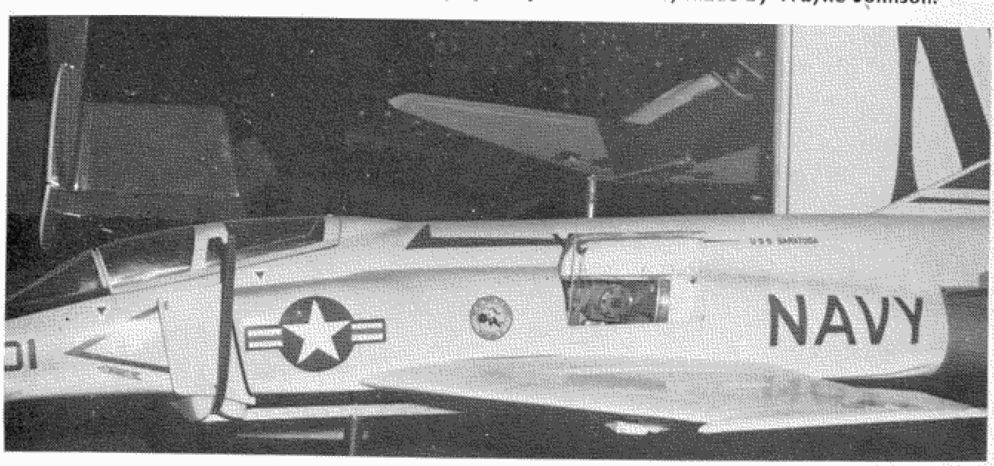


This design is rather as per the *Epee* design published in the December issue of *R.C.M.E.* 1972.

As can be seen from *Figs*. 3–6, a variety of scalish type shapes can be made without detracting to a great degree from the necessary intake and efflux areas in relation to the fan ring area.

Now to the next question that may be asked: "*What about the positioning of the fan in the duct, and how are the engine tank and cone mounted?*"

Seen at the 1974 Toledo R/C show, this Phantom has an internal Ross 80 twin ducted fan unit. Photo by Russ Brown. Model displayed by Ross Motors, made by Wayne Johnson.



It does appear that the most effective position of the fan is at approximately one-third of the duct length from the intake end as can be seen in *Figs.* 2–6. However, a variation on this can be made with no apparent detrimental effect: the nearer the fan is to the intake the more effective the "sucking" motion; but the length of the rear duct is then greater and so possibly adding friction between the air flow and the duct walls, and likewise if the fan position is too far back, the "sucking" motion of the fan is reduced and hence less air drawn in until the model is actually moving. So the effective position of the fan should be no more than 50% of the duct length and no less than 25% of the duct length respectively from the intake end. The faster the model travels, the more effective the whole unit, because when stationary the fan has to suck in still air, but when moving forward at any speed, more air is forced into the duct intakes, thus increasing the amount that can be used by the fan for conversion to propulsive power. It is interesting to note that when in a high-speed dive, the engine of a DF unit does not appear (or rather sound) as if it is over-peaking itself, as does a prop-driven aeroplane, even though air is being forced into the intakes at quite high velocity. Anyway, back to the positioning of the fan and engine in the duct. I have said that one third from the intake would seem to be the most effective position. However, there are other factors to be taken into consideration, the main one (and probably the most important) being the CG position of the finished model. Now one may well say, "Well a little bit out here and there, then add a bit of weight to the nose or tail!" but remember from the earlier paragraphs of this article how important the weight factor is with this type of model, and anyway how much better to build a model whose CG position is exactly right from the start.

The CG position of your model will depend on the shape of the wings. As most modern jet aircraft have swept or delta wings, these are the two types that I will deal with here. With a straight wing the best position for the CG (depending on the camber) is generally considered to be approximately one-third or 33⅓% of the chord from the leading edge of the wing, and this still holds good with the DF type of model.

With a delta wing, CG positions vary according to the sweep of the leading edge of the wing. I have set out a table below based on a thinned Clark Y section which I use and on my own experiments:

LE Sweep	*CG Position at Root Chord with incidence of 1°–2°*		*Stability out of 10*
	With Reflex	*Without Reflex*	
40°	48%	52%	5
45°	50%	54%	6·5
50°	50%	56%	7
55°	54%	58%	8
60°	60%	61%	9
70°	61%	62%	6
80°	62%	63%	4

An average position of the CG on a delta plan form would therefore appear to be 58% without reflex on the trailing edge or 55% with reflex on the trailing edge. (Reflex = washout.)

With the swept-wing model, once again the CG positions vary according to the sweep of the leading edge of the wing, but are slightly different for the delta plan form. Once again I have set out a table based on my results:

LE Sweep	CG Position at Root Chord with incidence of 1°–2°		Stability out of 10
	With Reflex	Without Reflex	
40°	40%	44%	8·5
45°	45%	48%	9
50°	50%	52%	9
55°	58%	60%	8
60°	61%	62%	8·5
70°	61%	62%	4
80°	62%	63%	3

An average position for the CG on a swept wing without washout would be 55·8% and 53·8% for a swept wing with washout on the trailing edge. The variation between swept and delta wings is partly due to the "bite" out of the trailing edge of a delta shape thus forming a swept shape. It will be noted that the 60°, 70° and 80° swept wings have CGs in approximately the same positions as their delta counterparts.

I have gone through the CG positions for these types of wing at this stage because this is the other factor we mentioned with regards to the positioning of the fan and engine in the duct. I always try and arrange for my CG positions to be just behind the engine and fan. (See *Fig.* 7.)

Fig 7

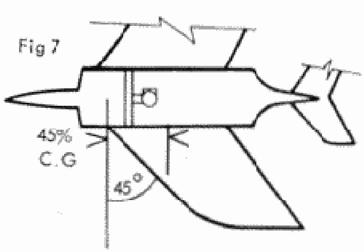
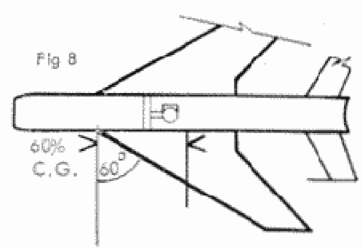


Fig 8

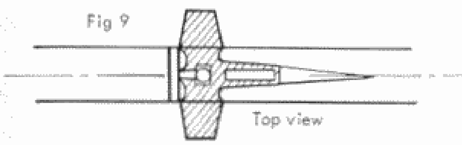


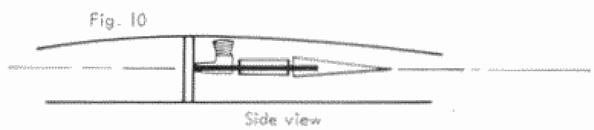
Now, as I stated before, sometimes the position of the fan and engine has to be a bit farther back than one-third of the duct length. This becomes apparent when building a model which has a leading edge sweep 55°–60°, and this is because the CG position on this type of wing moves nearer the trailing edge of the wing, as can be seen in the preceding tables, and I have drawn an example in *Fig.* 8.

As can be seen from these diagrams the fan position is now at approximately 40% of the length of the duct from the intake. I have built models with this positioning of the fan, with the "open hole" type intake and no apparent detrimental effect on thrust has been experienced. I would, however, think that a model with the "Elephant Ear" type of intakes, and wings of a highly swept angle and fan in the position shown would lose some efficiency in thrust over a similar model with the same type of intakes but with the fan and CG position as in *Fig.* 7.

Mounting the Engine and Fuel Tank

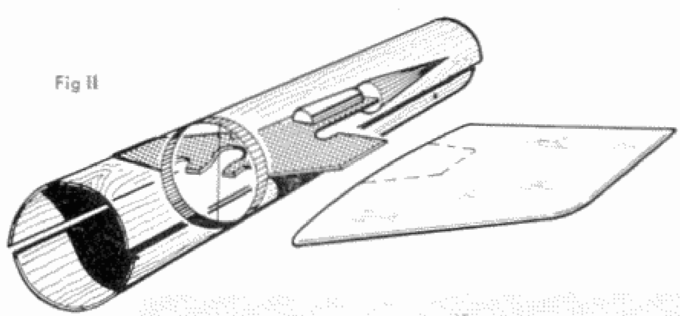
I find that the best method of mounting the engine and tank in the duct is to incorporate one engine-cum-wing tongue mount through the duct at right angles and on a horizontal plane (see *Fig.* 9) and on the Centre Line of the duct, (*Fig.* 10).



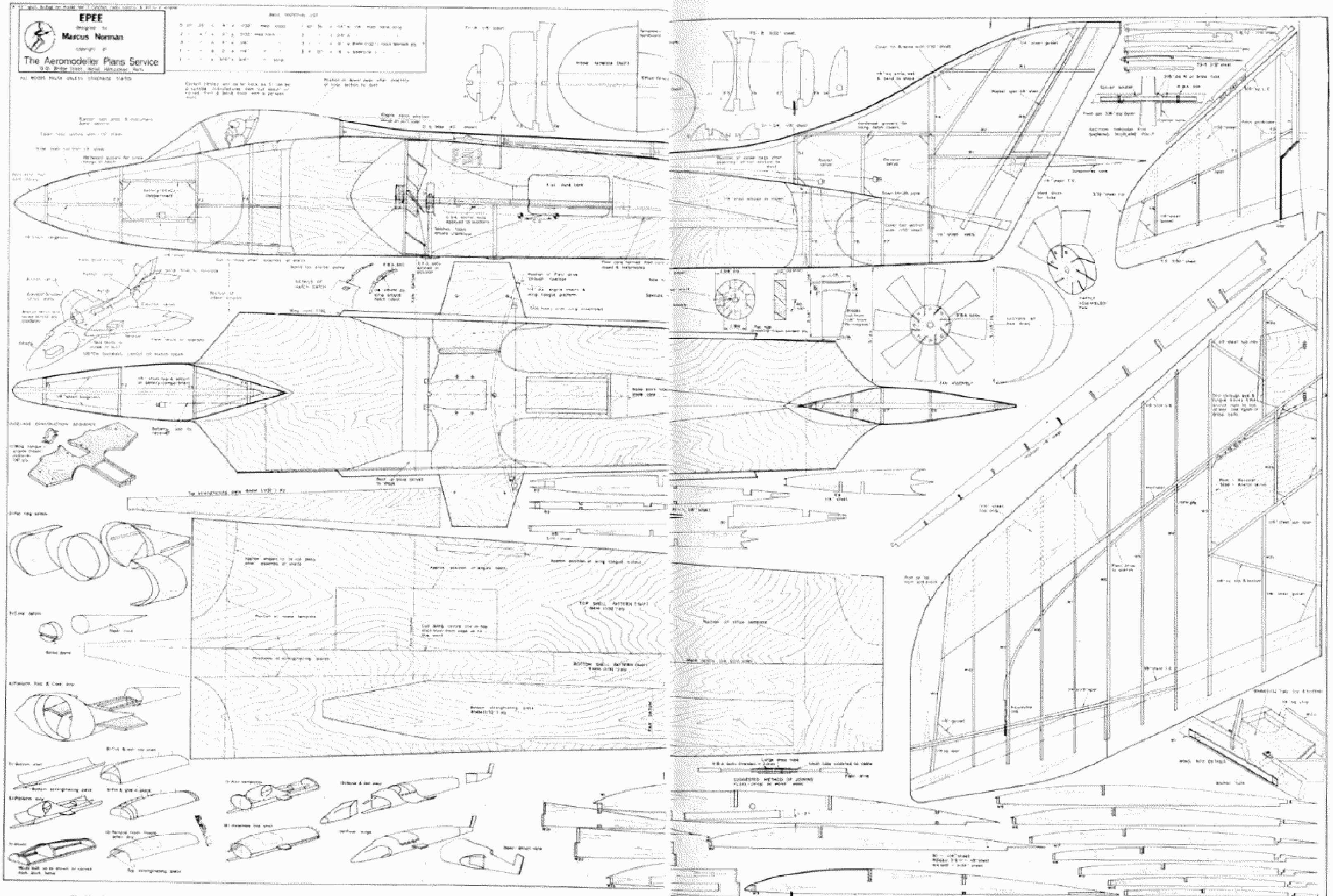


This method of mounting the engine, tank, cone and wings all on the same structure seems to be one of the most successful ways to date, at least as far as my experience is concerned.

The fan itself runs inside a pre-made ring with a clearance of approximately $\frac{1}{32}$ in. all round. The ring is fixed to the engine mount-cum-wing tongue, and it is upon this structure that the duct "shells" are fixed. I cut my wing-tongue-engine mount from $\frac{1}{4}$-in. ply resin bonded, and it has always proved a good sturdy method of construction. (See *Fig.* 11.)



Author holds "Epee"—plans on following pages. This design illustrates the methods of construction used to fulfill the requirements outlined in the article.



Full size copies of Marcus Norman's Epee design available price £1.45 from Aeromodeller Plans Service. P.O. Box 35, Hemel Hempstead Herts, HP1 1EE. Quote plan reference No. RC 1174 when ordering.

(B) Airframe Design
Fin and Rudder

There is not much to say about fin and rudder design, but the suggested sizes are shown in *Figs.* 3–6 are approximately the right size for each individual type. An important factor to remember with DFs is that there is no slipstream from an airscrew going over the fin and rudder surfaces. Because of this it is wise to keep the fin and rudder on the large side, and in fact this is in keeping with full-size practice on real jet aircraft, as many of you may have noticed. In general, however, the same rules apply as to the size of these items, as when building a conventional prop-driven model.

As far as the section of the fin and rudder are concerned, I find that a simple symmetrical section is best, with a refining of taper towards the tip. In free flight DFs, the fin and rudder can be quite thin, but on my radio models the elevator and rudder servos are mounted at the base of the fin and contained within its section, and so consequently the section is a bit thicker to accommodate these items at the root. There does not seem to be any detrimental effect caused by this on the model's flying characteristics. However, try and keep the section as thin as possible as too thick a section creates drag (another thing to keep to a minimum when building DFs).

(C) Tailplanes, Elevators and their Positions and Sections

Having chosen the type of wing and tail configuration that one intends to use on one's model (i.e., delta, swept, or even straight wings), it may be asked, to what position the tail should be placed at in relation to the fin and rudder.

On my free flight models I usually place the tail (as did "P.E.") near the top of the fin and rudder. (See *Fig.* 12.)

When placing the tail in this position, it will be found that a negative incidence of approximately twice the amount as the positive incidence of the wing will be required, providing the CG, etc., is in the correct position (i.e., if the wing is set at 2° positive, then the tail will be approximately 3–4° negative, the line through the centre of the section being taken as the point to mark off the –3°).

Fig. 12

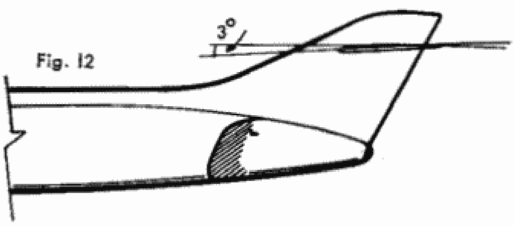
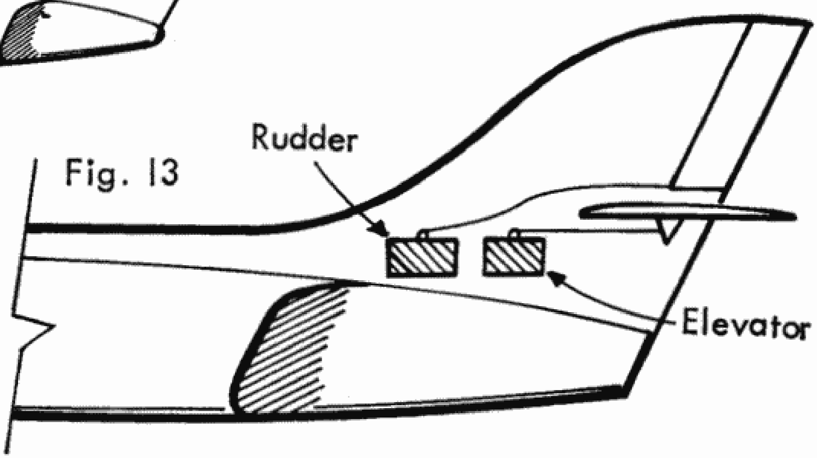


Fig. 13



When building a radio model, I place my tail at approximately midway between the tip and the root of the trailing edge of the rudder. (See *Fig*. 13.) The main reason for this is to facilitate a straight drive from the elevator servo to the elevators, or in my case all-movable tailplane.

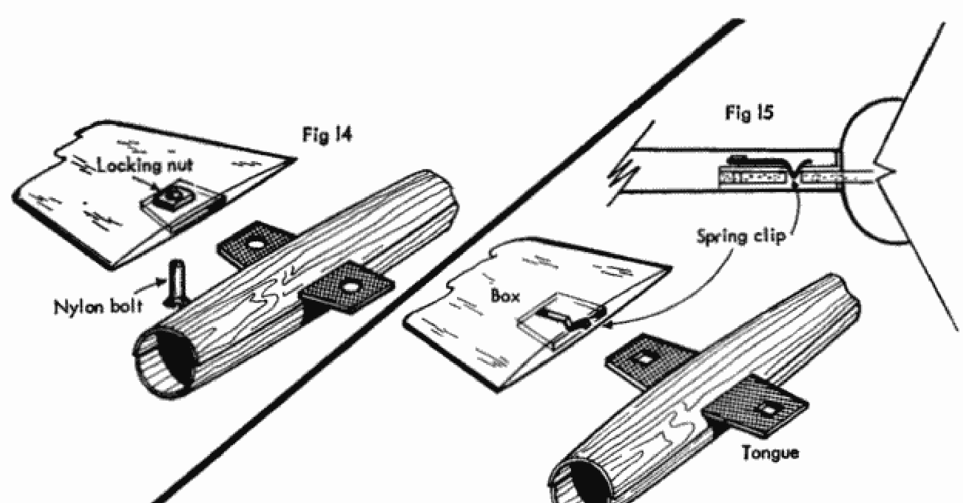
A flexi snake drive is used to the rudder.

I usually make my tailplanes all moving, their pivot point being on the mean chord line of the tailplane. I do this because, as mentioned before, there is no slipstream from a propeller over these surfaces, and the large movable area of the tailplane provides plenty of control even when the model is flying slowly or on the glide.

The section for the tail is again a symmetrical section, thus the tail (providing the CG is in the correct place) is merely a "stabilizer". If, however, the aeroplane has a fairly long distance between the CG position and the centre of the tail (moment arm). I quite often increase the curve of the camber on the top of the tail and decrease the camber slightly on the bottom, thus providing a certain amount of lift from the tail surfaces. Likewise, where the moment arm is fairly short (i.e., say one-third of the mean chord of the wing being approximately the same distance as is the tail from the trailing edge of the wing), I increase the camber on the top, thus the tail tends to keep the tail end of the aeroplane on the level. The tail section, like the rudder and fin section, tapers towards each tip respectively.

(D) Wings: Fitting, Incidence and Sections

On all my models the main wing consists of two panels (left and right), which are secured either side of the duct (fuselage) on the wing tongues provided by the engine mount-cum-wing tongue. Each wing panel has a box secured in the roots, which fits over the respective tongue. On my radio models a nylon bolt passes from the underside of the wing, through the box and tongue and through the top of the box into a locking nut fixed on the topside of the wing box. In the case of my free flight models, a spring clip (made from clock spring shaped and re-tempered) holds the wing and box in position on the wing tongue, this allows the wings to knock off in the event of a heavy crash. (See *Figs*. 14 and 15.)

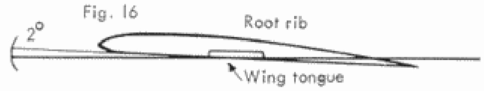


These methods of fixing seem to be very satisfactory and quite simple.

The position of the wing on most of my more successful models is at midpoint because of the ease of incorporating the wing tongue-cum-engine mount as one, and also because of this fact there is no excessive interference with the duct inside as there would be with a one-piece low wing or shoulder wing.

The wings are usually set at a position which offers the lowest drag and at the same time gives a good lift angle and this position I find has an angle of incidence of $1\frac{1}{2}$–2° (the deltas are usually $1\frac{1}{2}$° and the swept wings usually 2°), taking the tongue as being at the horizontal. (See *Fig.* 16.)

Fig. 16



I find the easiest way of setting this up is to cut two root fillet ribs and set these in position over the tongue against the side of the duct and then glue them. The wing can then be set in position, having first placed the wing box over the wing tongue. The thing to be careful of is that you make sure that both wing panels are the same, otherwise a turn will result one way or the other.

I use a thinned Clark Y section for my wings, as this gives a low drag but a good lifting capability, and another advantage is that it possesses a few vices. The section on free flight models can be as thin as is practical, but on radio models, the thickness of the wing is governed by the height of the receiver. (I mount the Rx in one wing and the servo for aileron in the other.) This section thins out towards each tip. I construct my wings with a full-depth mainspar which runs from root to tip, and it is the mainspar which governs the coordinates of each rib when all are sanded down to their appropriate section. The mainspar should also be arranged so that it crosses the wing tongue box at the root end, thus providing added strength at the mounting points on the tongue.

Weights and Wing Loadings

As with most aeroplanes, the greater the weight the greater the wing area required for minimum flying speed, and, subsequently, the greater the power needed to propel the aeroplane forward to obtain that minimum speed.

Now, bear in mind what has been mentioned earlier in the article with regards to power-weight ratio. (When designing a DF model, it has got to be built around a particular engine, etc., you cannot just stick a larger engine in, if it seems underpowered.) In other words, a fairly accurate estimate of the finished and flying weight of the model is needed, and from this can be determined the minimum amount of wing area is required for flying that particular model. Obviously, one doesn't want a model jet aircraft to look like a sailplane (or maybe some do), and so to preserve a jet-like appearance one has to try and incorporate the aesthetic qualities with the practical application, this being in much the same fashion as with the scale modelling.

P. E. Norman worked on a basic formula of: 1 *lb. per* 1 *sq. ft. per* 1 *c.c.*

This worked very well for the earlier diesel-driven models and is a good formula for free flight models. However, with the much improved power available from glow motors, I now work on a formula of: 1·5 *lb. per* 1 *sq. ft. per* 2–2·5 *c.c.*

This seems to work very well, and is approximately the way most of my RC models come out. It will also be noted that it does in fact show some proof that my latest fans give an improved performance. I have in fact built a scale model Supermarine Scimitar which had a wing loading and area of: 2 *lb.*

per 1 *sq. ft. per* 2 *c.c.*, but although it flew quite well, its performance was somewhat lacking this being mainly due to the rather high wing loading and the fact that the engine was the O.S. Max. 40. I do feel, however, that had I had my K&B racing motor available at the time, the results would have been even better. I have used this example as an indication of what happens when the model is a little over-weight, thus giving it a higher wing loading.

Conclusion. The use of two formulas which give excellent results in the field of DF design: (1) 1 *lb. per sq. ft. per* 1 *c.c.* (2) 1·5 *lb. per* 1 *sq. ft. per* 2–2·5 *c.c.*

With regards to wing area, although generally swept and delta wings have a shorter span than a straight wing of equal area, they can still maintain a very effective wing area. Another advantage with the swept wing is that little or no dihedral need be incorporated (e.g. it is usually accepted that 10° of sweep = 1° of dihedral.). Therefore with a swept wing of 45° an effective dihedral of 4° can be assumed. It will be noted, however, from my previous tables on swept and delta wings that when the sweep exceeds a certain number of degrees, then the stability becomes less.

To find the areas of swept and delta wings is relatively easy, but I have sketched out a rough guide for doing this in *Figs.* 17 and 18. I do not include the width of the fuselage in these areas as I calculate each wing separately and then add the two.

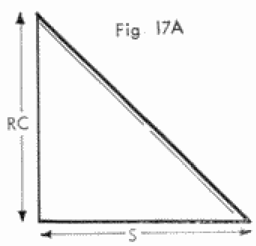


Fig. 17A

RC=Root Chord
S=Span
TC=Tip Chord

$$\text{Area} = \frac{S \times RC}{2}$$

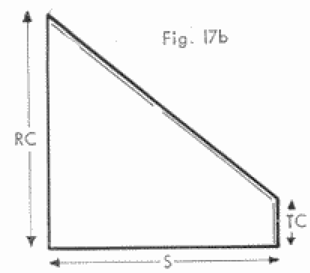
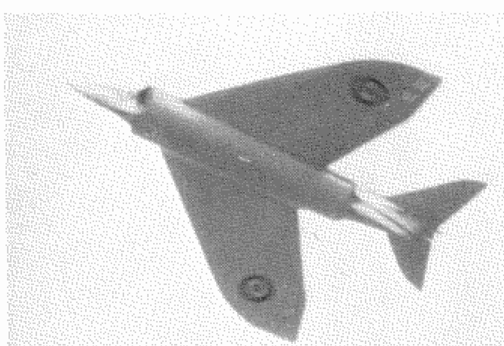


Fig. 17b

$$\text{Area} = \left(\frac{RC + TC}{2}\right) \times S$$



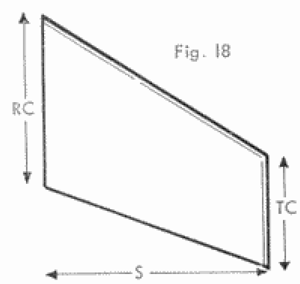


Fig. 18

At left, "Epee" in flight, a graceful shape.

I personally do not include any tail area or fuselage area as lifting. Therefore, if these two items do provide any lift, then it is as added bonus on the design areas!

A source of weight that is not apparent on the scale is to a small degree the drag of the aeroplane. In consequence, it is advisable to keep your design as clean in shape as possible. Since I have introduced drag as a source of weight, I will also deal with the subject of undercarriages. Many people have asked me when I have been flying, "Why don't you have an undercarriage on it?" In my mind there are two basic answers. The first is that an undercarriage not only adds weight in the form of mass but also in the form of drag, the second reason is that not many jet aircraft fly around with their undercarriage dangling. I can envisage a retracting undercarriage but at the moment a hand launch or a dolly take-off is adequate. "Did he say dolly take-off?" Yes, I, did. Most of my models will take off a dolly undercarriage, although the surface must be as flat as possible and fairly long. The necessity for which will be observed in the next section.

Summary of Weights and Wing Loadings

(1) *On for example an aeroplane weighing 4·5 lb. (including fuelled tank of 6 oz.) and incorporating 2–3 channel RC, the best wing area would be 3 sq. ft., giving a loading of 1·5 lb. per sq. ft.*

(2) *For an aeroplane of 4 lb. weight (tanked up), the area would be 2·5–2·75 sq. ft. giving a loading of 1·6–1·4 lb. per sq. ft.*

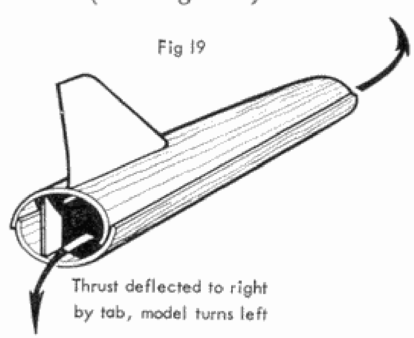
(3) *For an aeroplane of 3·5 lb. (tanked up, say, 2–4 oz.), free flight or single channel an area of say 2–2·25 sq. ft., giving a loading of 1·7 or 1·1 lb. per sq. ft.*

Flying Characteristics: Free Flight and Radio Models

When testing my models (both free flight and RC) I always try a glide first. Old fashioned? Maybe, but I feel it is a good idea as far as I'm concerned. A nice flat glide with no tendency to stall or dive rapidly is best for this type of model (or any others, come to that). Having carried out the glide tests and satisfied oneself that all is correct, then the next step is powered flight.

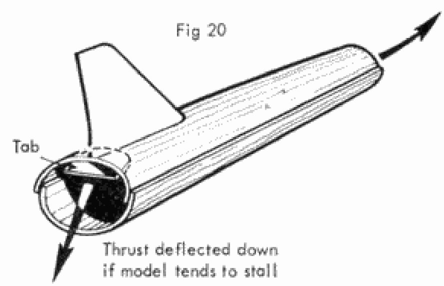
With a free flight model one should aim at a left-hand turn under power and a gently turning glide after engine has cut. I always test a free flight model with almost peak power, and one is able to do this because in general (providing the model has been built in true alignment) there is very little torque or gyroscopic torque to left or right. If there is a pronounced turn to left or right, then a trim tab should be inserted in the efflux on the same side towards which the model turns. (See *Fig.* 19.)

Fig 19



Thrust deflected to right by tab, model turns left

Fig 20



Thrust deflected down if model tends to stall

The trim tab deflects the thrust to the right thus forcing the efflux over to the left and therefore keeping the model on a straight cruise. The same process is used on RC models if an excessive amount of aileron or rudder is needed to keep the model straight when flying under power.

Another important trim tab that will probably be required is the downthrust vane. (I have not built a model yet which does not require downthrust of varying degrees.) I build all my models with a downthrust vane as a matter of course now. (See *Fig.* 20.)

If too much downthrust is incorporated, the model will either dive under power or need a lot of up elevator to make it climb. If on the other hand the model has not got enough downthrust she will stall. With this type of model it is a kind of "mushing" stall, and one can tell soon after take-off whether this is due to not enough downthrust, as she will quite suddenly put the nose up and wallow down in a stall attitude. I always fix my downthrust vane in when building the model, and if she requires less downthrust, I gradually trim the vane back until the correct position is found. Of course one can make an adjustable variety vane if so required. With RC models one does have the use of the elevator, but if for instance a lot of down is required to fly the model under power, then when the engine cuts and it is in the glide a lot of alteration of trim will be necessary.

When testing radio models under power, I use peak power, because with radio one can control the aeroplane. When the first flight has ended (successfully we hope) then alteration to sidethrust and downthrust can be effected if so required.

When flying a DF with multi radio it is advisable to make sure the hand launch is fairly flat, I usually launch my models using the two-handed method, and make sure that I have a competent pilot on the transmitter. Having launched the model, it should be kept fairly level, enabling it to build up a bit of speed before climbing away. DFs seem to take a little longer to accelerate to their best flying speed, and so one must always be a little careful with handling the model to start with. When using a dolly, it is obviously easier as the model will only lift-off when its minimum flying speed has been reached, but one still has to be careful not to climb away too steeply initially. It's rather like flying a scale model actually.

If you are not a very experienced flyer (like me), then let someone else fly it initially for you. Once in the air a DF model will handle like any other, loop, roll, etc.

As yet I have not bothered with throttle control, but a throttle servo could easily be incorporated in the wing and a flexi-drive connected to the throttle, much as in the same way as I do with my aileron drive.

American design by Bob Violett uses the Scozzi duct unit introduced to the U.S. market mid 1974. Powered by K&B 40, it demonstrated a full range of aerobatics at the 1974 Scale Championships, Lakehurst.

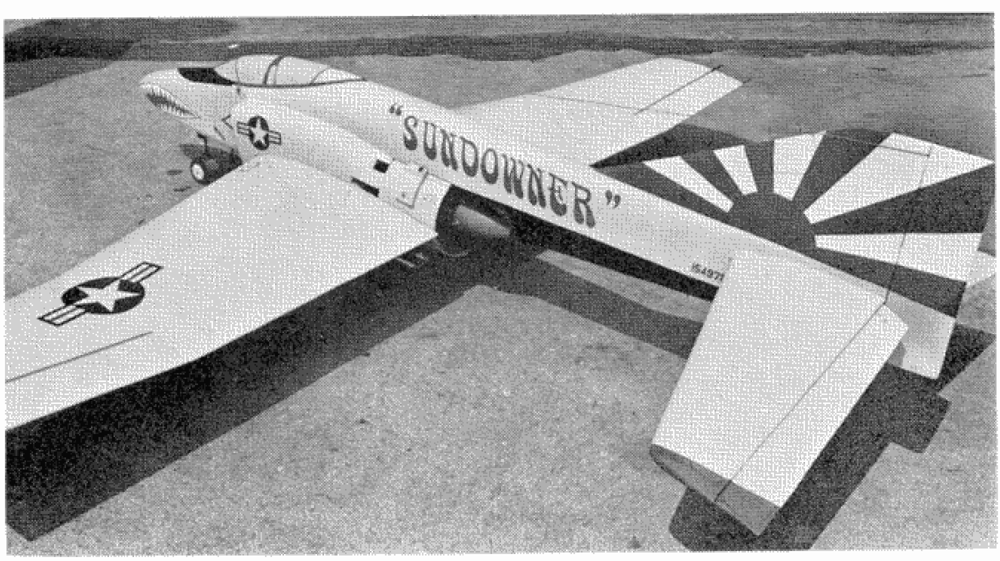


Fig 21

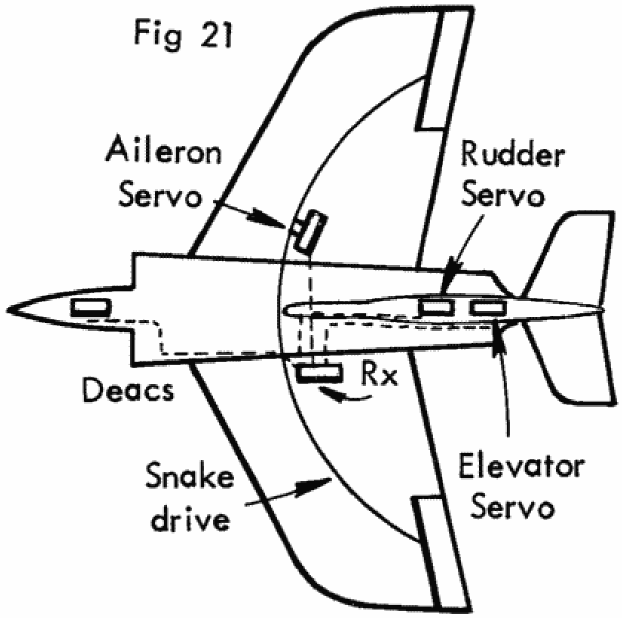
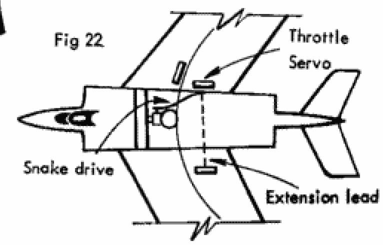


Fig 22



Suggested Methods of Installing Radio Gear

With the fuselage consisting partly, or wholly, of a through duct, one might wonder where to put the various items of radio gear, and so I will describe the methods I have used successfully.

I always try to install my batteries in the nose section, or in the case of Russian type designs (where there is no separate nose), just behind the cockpit. I use the DEAC 280 pack which is small and compact.

My receiver is installed in a compartment usually in the port wing (looking from the rear of the aeroplane).

My aileron servo is installed in a similar compartment but in the starboard wing, a snake drive runs from left to right aileron in a gentle arc passing across the wing tongue-cum-engine mount and just behind the engine.

The elevator and rudder (if used) servos are installed within a compartment in the fin of the aeroplane (as previously illustrated in *Fig.* 13). On my latest models I have not bothered with a rudder control as one only needs it if a lot of dolly take-offs are contemplated, or complicated aerobatic manoeuvres are required. In *Fig.* 21 I have sketched these installation ideas in a plan view.

Extension leads are needed for this layout, one from battery to RX, one from aileron servo to RX, and two from elevator and rudder servos to RX.

The leads are firmly taped with nylon ribbon doped on where they pass along the walls of the duct on the inside.

As I have previously stated, a throttle servo could be installed in one wing with a snake drive to the throttle. (See *Fig.* 22.)

This is a suggested method for incorporating a throttle servo, and is the method which I intend to use when I use a throttle.

All the servos are mounted on double-sided mounting tape.

SCALE MODEL DUCTED FANS AND THEIR DIFFICULTIES

I have had a number of persons writing to me (following the article published in *R.C.M.E.*, December 1972), asking advice on the possibilities of scale model ducted fans, as a result I will give some advice on this subject in relation to my own experiences in this field.

I have built five actual scale ducted fans and these comprise : Two "*Lightnings*" (free flight and single channel); "*Phantom*" (free flight and not very satisfactory); a *Boulton and Paul P.111*; a *Supermarine* "*Scimitar*".

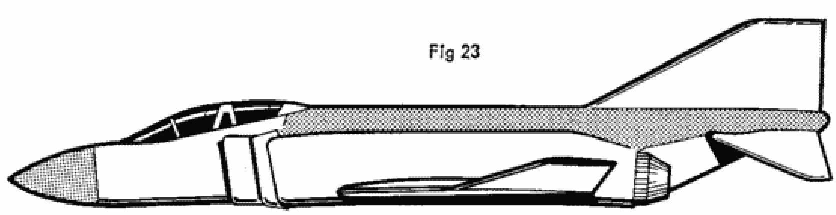
I have already mentioned that my "*Lightning*" was in fact my first successful DF model, and it was as near scale as possible. However, a certain amount of "cheating" had to be done with regards to increasing the intake area, fan (centre fuselage width) and efflux area. My free flight "*Phantom*", with its low wings, wide fuselage and small wing area was not successful.

The *Boulton and Paul P.111* (a tailless delta aeroplane, built in the fifties) is a radio model and was built virtually to scale (i.e., scale intake area), slightly enlarged efflux area. It carried three channel radio gear, ailerons, separate trailing edge elevators and rudder. This model was fairly heavily loaded and was rather tricky to launch because of the short fuselage and hence short moment arm. It tended to stall rather badly at first, but having added some weight, (I just had to – no other way) to the nose and incorporating more downthrust, it flew quite well, but the engine tended to overheat and stop after a short flight. This was probably due to the model having such a small intake area.

My next scale model was the *Supermarine* "*Scimitar*" (now this is the aeroplane upon which the *Epee* design is based). The "*Scimitar*" had to have a slight increase of efflux area and wing area, otherwise almost true scale. As I have already mentioned, my model came out rather overweight and was underpowered with the Max. 40 but it nevertheless flew quite well, and in fact I am contemplating building another one but this time slightly smaller and having the K&B pylon engine in it.

It is my opinion that most scale model ducted fans are rather tricky due to their real counterparts having usually small intakes and effluxes. Wide fuselages (which necessitate building out the fan ring at the sides with balsa block to obtain the required section), awkward fuselage shapes making them difficult to form with $\frac{1}{32}$-in. ply (especially where double curves are required), small wing areas for their overall size and quite often, as with a great number of modern jet aircraft, what I call "excessive baggage". By this I mean parts which have no function whatsoever on a model aeroplane. For example, see *Fig.* 23.

Fig 23



In this side view of the "*Phantom*", the shaded areas represent what I would term "excessive baggage", i.e., the nose is not only an awkward shape but is rather on the long side. The dorsal spine is of considerable width and height. The depth of the duct is rather shallow, while the width of the duct when viewed from the top is excessive. The wing area is small and the tailplane has that 23°

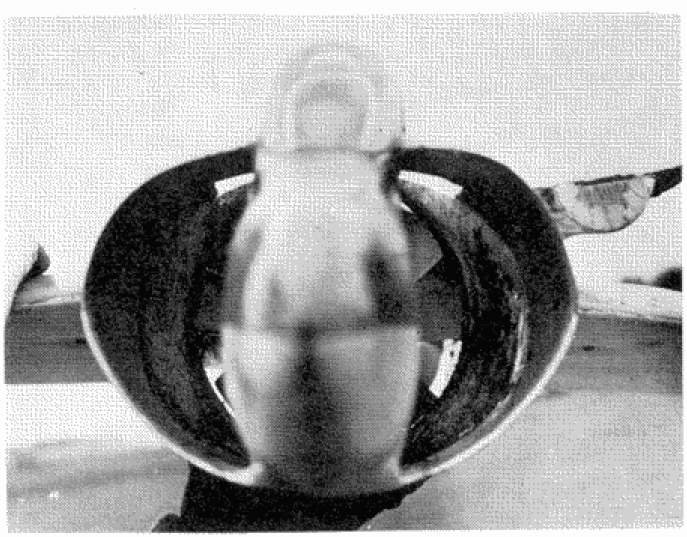
of anhedral (no wonder my free flight one wasn't successful!). As I have just stated, the "excess baggage" means unwanted weight.

Even the *Supermarine "Scimitar"* has some excessive baggage in that the tail section of the fuselage is rather long and the width of the fuselage when scaled so as to be able to use my 5-in. diameter fans, comes out at 7 in. wide, which means surrounding the fan ring with balsa block and then ovalling to section.

I have concluded, therefore, from my experiments that the number of "actual scale" models that could be built successfully using the DF system are somewhat limited in number, and most require some "cheating" one way or another. I have set out a table below, using a 40-size motor driving a 5-in. fan, and giving the approximate span, length, wing area and loading and expected finishing weight of six possible scale model ducted fans.

Type	Fan Dia.	Depth Duct	Width Duct	Total Length	Span	Scale Wing Area	Weight	Max. Wing Loading	%/10
"Scimitar"	4 15/16	5″	7″	48 1/8″	32″	2·25 sq. ft.	4–4½ lb.	2 lb./sq. ft.	5/10
"Gnat"	4 15/16	5″	6″	56¼″	39¾″	1·5 sq. ft.	4–4½ lb.	2·25 lb./sq. ft.	4/10
"Phantom"	4 15/16	5″	7″	66⅔″	43″	3·3 sq. ft.	4½–5 lb.	1·8 lb./sq. ft.	5/10
Dassault "Etendard"	4 15/16	5″	6¼″	48¾″	34″	2·5 sq. ft.	3¾–4 lb.	1·5 lb./sq. ft.	8/10
Dassault "Mystere"	4 15/16	5″	5″	40½″	39″	2·6 sq. ft.	3¾–4 lb.	1·5 lb./sq. ft.	8/10
Mig 15	4 15/16	5″	5″	39¾″	37″	2 sq. ft.	3¾–4 lb.	1·8 lb./sq. ft.	7/10
Mig 17	4 15/16	5″	5″	39¾″	36½″	2 sq. ft.	3¾–4 lb.	1·8 lb./sq. ft.	7/10

This table gives a rough guide to a small number of scale models that could be built with some success, as will be noticed. At the end of each type of summary, I have awarded a percentage out of ten to indicate what I think would be the degree of success for each model. In most cases each type requires increase in wing area intake and efflux sizes. However, out of the types mentioned, the two French types "*Etendarde*" and "*Mystere*" are nearest to the formulae required for success mentioned in this article.



Ply formed intake for Epee, leading to 5 in. diameter fan, see plans pages 20–21.

MATERIALS AND SOME IDEAS FOR THE CONSTRUCTION OF A DUCTED FAN MODEL

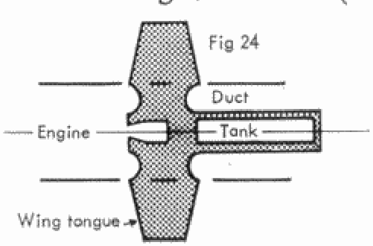
A brief Summary of Materials used.

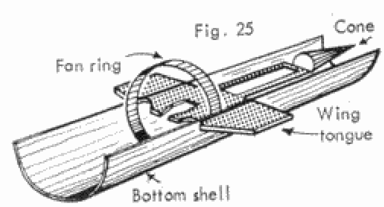
1. *Engine Mount-Cum-Wing Tongue*
   ¼-in. resin bonded 5-ply wood of good quality and free from warps.
2. *Fan Ring*
   $\frac{1}{16}$-in. × 1¼-in. ply strip. Grain running lengthwise.
3. *Duct*
   $\frac{1}{32}$-in. ply (bends easily and is strong, will glue with epoxy or a good wood glue of resin type).
4. *Nose and Tail Blocks—if required*
   Polystyrene foam sheeted with $\frac{1}{16}$-in. balsa and nylon covered or Polyesterene block, tissue and nylon covered. (Treat first with emulsion water-based paint to fill pores.)
5. *Fin and Rudder*
   Balsa sheeted as far as mainspar both sides with $\frac{1}{32}$-in. sheet balsa built up construction ⅛-in. × $\frac{1}{16}$-in. ribs, spars, etc.
6. *Wings and Tail*
   Balsa ¼-in. root ribs, ⅛-in. sheet remainder of ribs. ⅛-in. hard full depth mainspars. Sheeted $\frac{1}{32}$-in. leading edges top and bottom back as far as mainspars.
7. *Wing Boxes*
   $\frac{1}{32}$-in. ply top and bottom; hard ¼-in. balsa sides and ends epoxied and pinned with ½-in. shoe brads, peened over on reverse side.
8. *Wing Fixings*
   RC models: Nylon bolts through boxes and tongue into locking nut fixed on topside of box.
   Free flight models: Spring clips (from clock spring) to snap into recesses in wing tongue.
9. *Fan*
   Hub from either ½-in. 5-ply resin-bonded marine plywood, mahogany ply made up from lamination and glued with epoxy or Duralumin turned up on lathe.
   Blades $\frac{1}{16}$-in. or $\frac{3}{32}$-in. "Permaglass" or $\frac{3}{32}$-in. Polycarbonate.
10. *Covering*
   Lightweight nylon wings and tail, rudder and fin, nose and tail blocks. I do not cover the duct, but lightweight tissue could be used to give a better finish over joins.

A Brief Summary of Construction Methods

The wings, tail, fin rudder and spine are of a conventional built-up construction sandwich method for ribs and full depth mainspars.

The duct part of the fuselage is made from $\frac{1}{32}$-in. ply. I use a bottom and top shell. The ply engine mount-cum-wing tongue is made first with the necessary cut-outs for Engine & Tank. (See *Fig*. 24.)





The next item to be made is the fan ring. This is made from $\frac{1}{16}$-in. ply wrapped round a disc of required diameter; the disc being removed when the ring has glued and set. The fan ring is attached to the engine mount, having first placed the engine in position on the engine mount-cum-wing tongue bolted in place. The fan ring is placed over the disc used for its construction and then the disc is mounted on the engine, the fan ring is then glued to the mount, this ensures that the crankshaft of the engine is dead centre of the ring. At this stage, if the fuselage has to be of an oval section, then the sides of the fan ring (outer) will have to be built out with balsa block and carved to shape.

The next items are two strengtheners slipped over the wing tongues and glued in position at the point where the duct walls will meet the ring in *Fig.* 24, the duct wall positions are indicated.

The bottom shell can now be placed in position and glued and also the rear cone see *Fig.* 25.

The next stage is to make the top shell. If a shape is required where a double curve is needed, this is quite easily obtained, by making a slit up the centre line back as far as the beginning of the curve required, and then by overlapping the ends and gluing securely, a curve will then result. (See *Fig.* 26.)

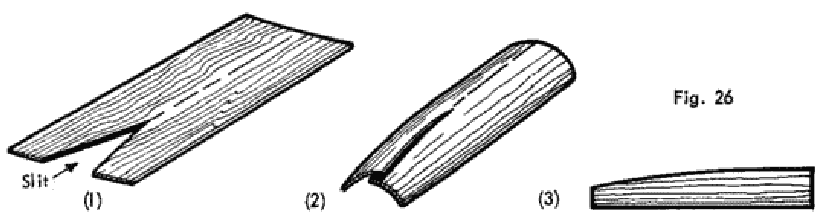
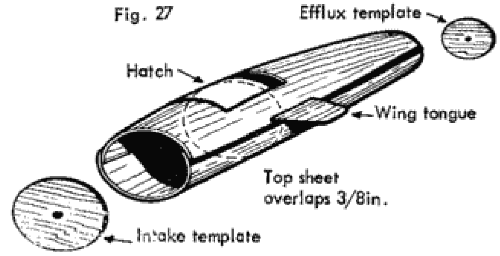


Fig. 26

If a curve is required at both ends, then the process is repeated, likewise if the bottom shell also requires a curve on it, then this process must be carried out before fitting it to the fan ring and tongue.

Having made the top shell, it can now be placed in position over the fan ring, thus forming the top half of the duct. Take care not to glue it on the section of the fan ring which coincides with the engine access hatch which will have to be cut out after assembly of the two shells. Two templates for the intake and efflux shapes will have to be cut to put in position while the top shell is gluing in position. Once the glue is set, the templates are removed and any binding that has been placed to hold the two shells together. You are now left with the duct section of your fuselage. (See *Fig.* 27.)

Fig. 27

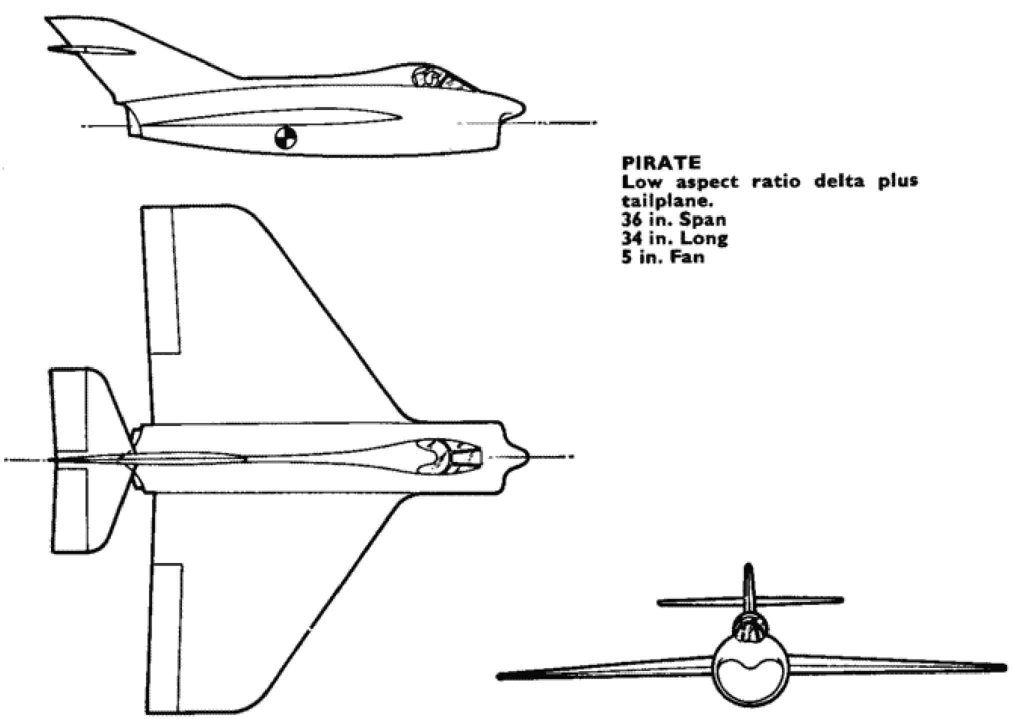


Having made the duct you can now add nose and tail blocks as required and all the other odds and ends already mentioned.

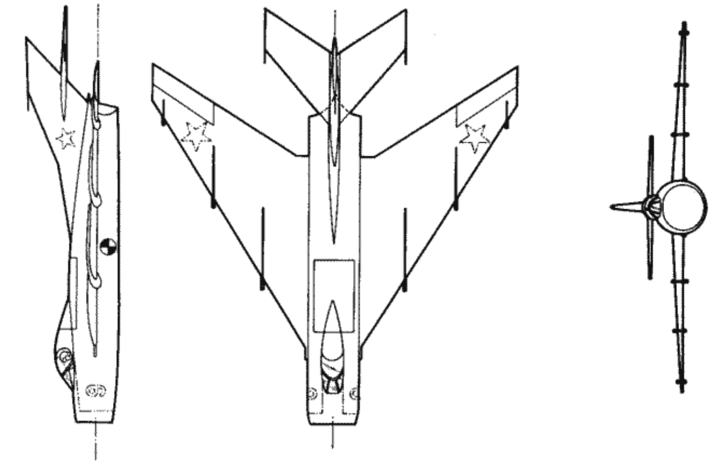
DFs are not as hard to construct as one might imagine and the resultant structure, using the methods I have described, is very strong and also fairly light. As one becomes more proficient at this form of construction, obviously everthing becomes much quicker, and in fact with the modern 5-minute epoxy glues, I can construct the entire duct as illustrated in an evening (4 hours).

I will set out once more the essential points required for the design and building of a DF model and at the end of the article are a number of 3-view drawings (one-sixteenth scale) that I have designed.

1. Intake area 88–100% of fan circle area.
2. Efflux area 75–80% of fan circle area.
3. Good power-weight ratio engine.
4. Well-made fan.
5. Average duct length 23 in.–35 in. (40 powered models).
6. Fan placed if possible at 33% in from the intake end of duct.
7. Wings thinned Clark Y section set at 1½–2° incidence.
8. Tail symmetrical thin section also rudder and fin.
9. Weight kept to a minimum.
10. Careful calculation of C.G. position.
11. Lightest wing loading possible but up to approximately 1·6 lb/sq. ft.
12. Nylon cover (light weight) for added strength.
13. Well fuelproofed inside of duct.
14. Careful initial testing.

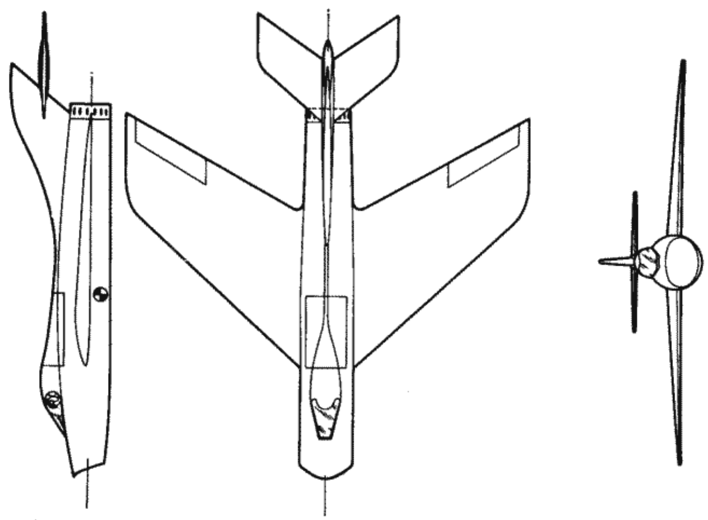


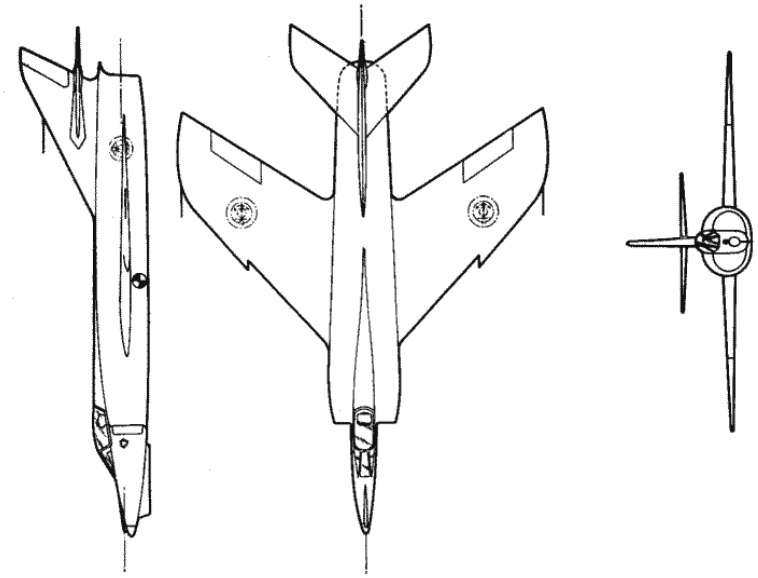
PIRATE
Low aspect ratio delta plus tailplane.
36 in. Span
34 in. Long
5 in. Fan



FIRELIGHT 36 in. Span. 40¼ in. Long. 4 lb. 2½ sq. ft.

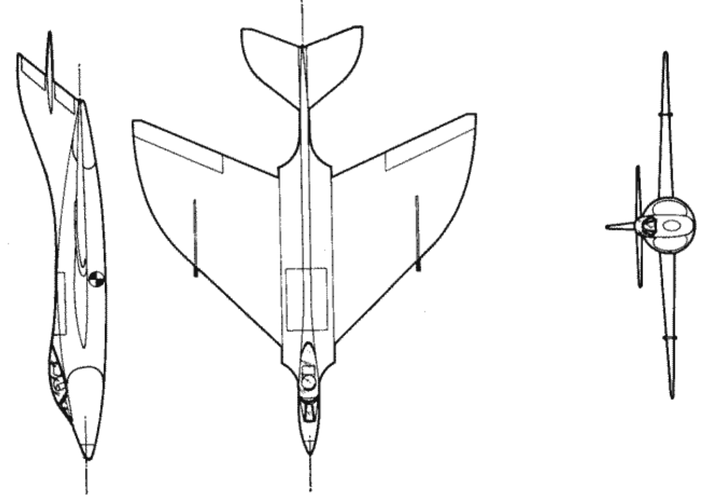
SKYLARK 40 in. Span. 46 in. Long. 4¼ lb. 3 sq. ft.

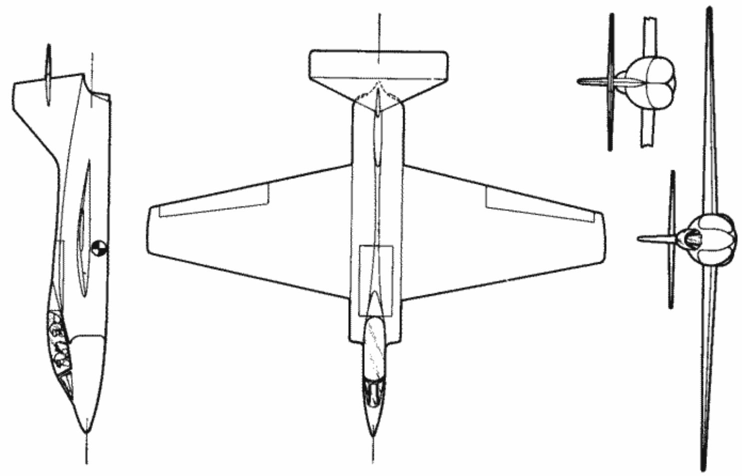




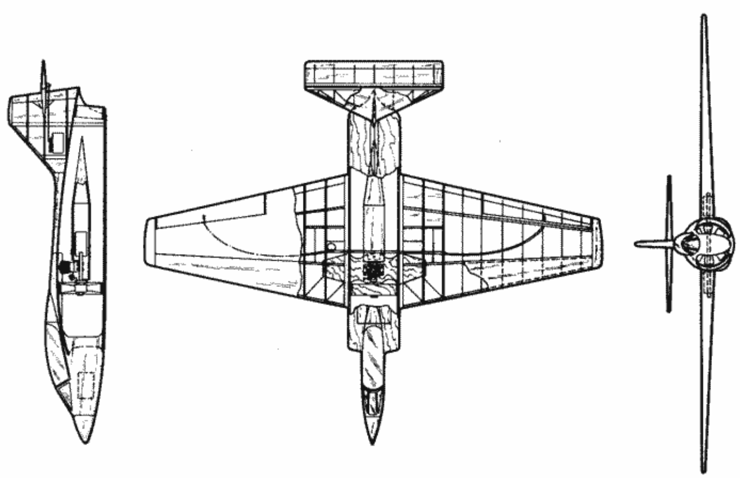
ETENDARD 37 in. Span. 48 in. Long.

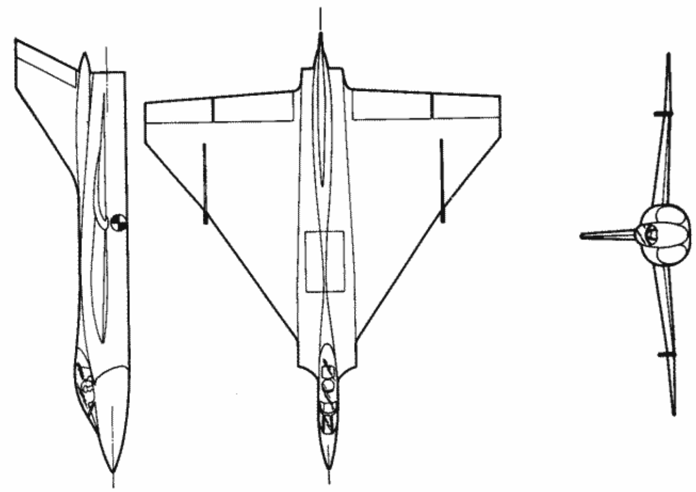
STILETTO 35 in. Span. 39 in. Long. 4 lb.





LAPWING 46 in. Span. 38 in. Long. 4 lbs. 2·6 sq. ft.
Structural view below illustrates duct, cone and motor (·40) positions. 5 in. diameter fan, wing loading 1·53 lb. per square foot. A straightforward design, built as Epee, see pages 20, 21 for details.

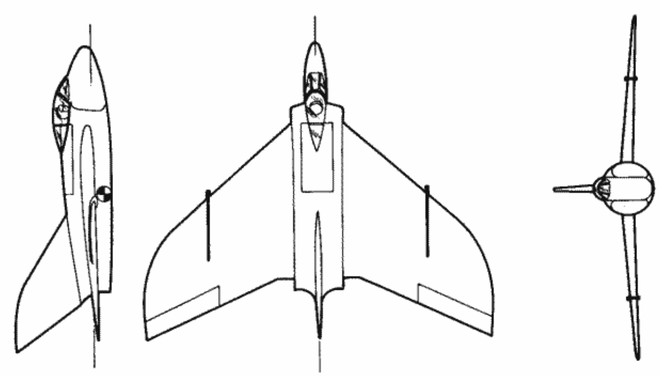


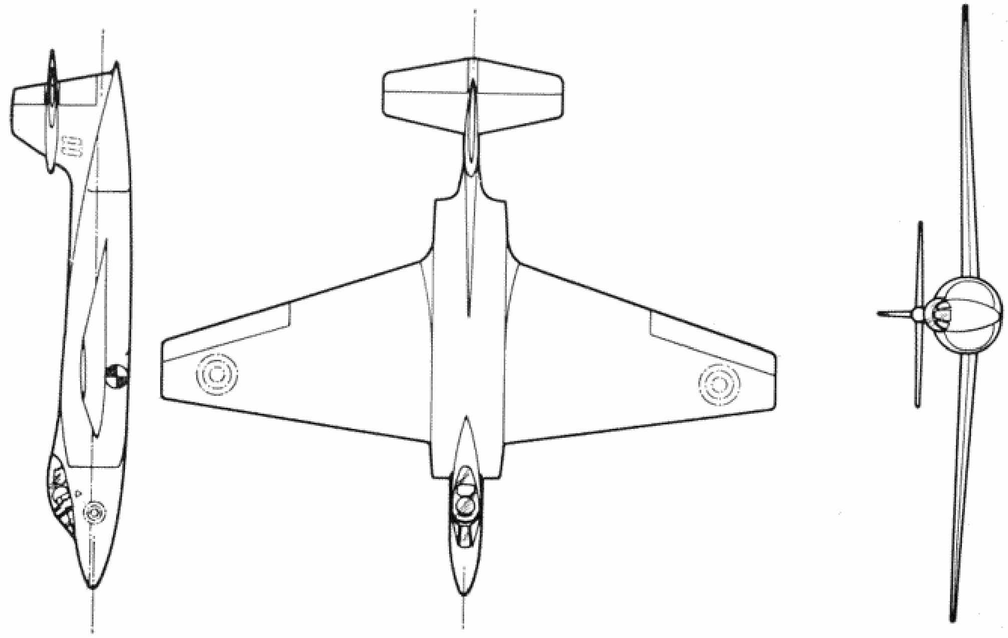


TRITON 36 in. Span. 44 in. Long. 4½ lb. 3 sq. ft.

Two delta style designs for ducted fans using variations of wing plan shape and length of fan duct.

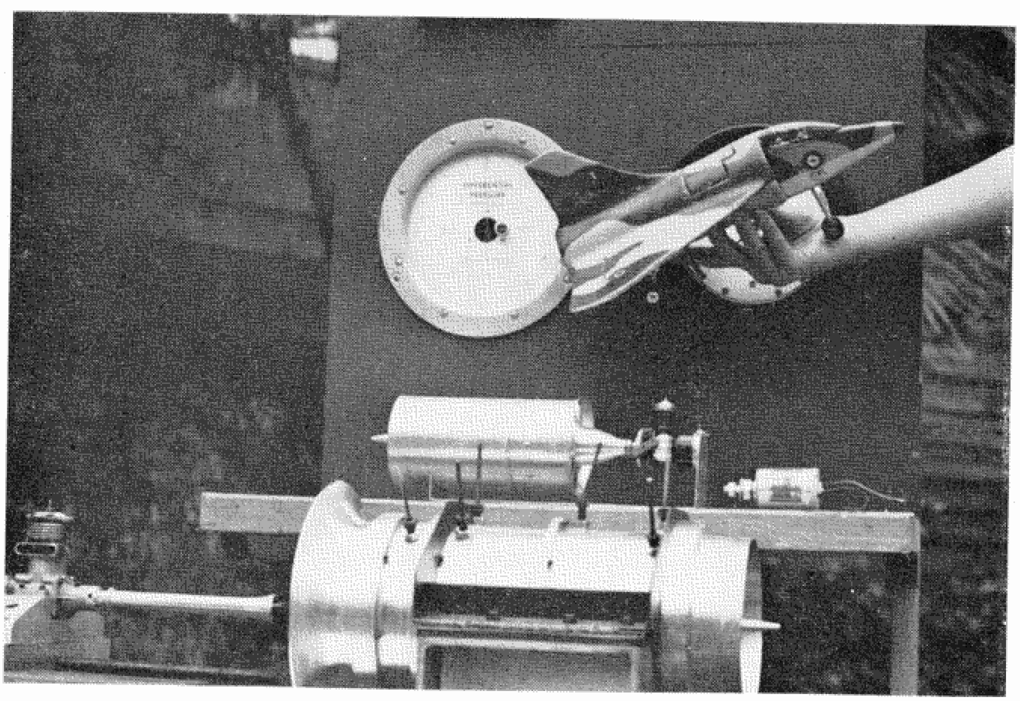
SWALLOW 35 in. Span. 31 in. Long. 3¾ lb. 2½ sq. ft.

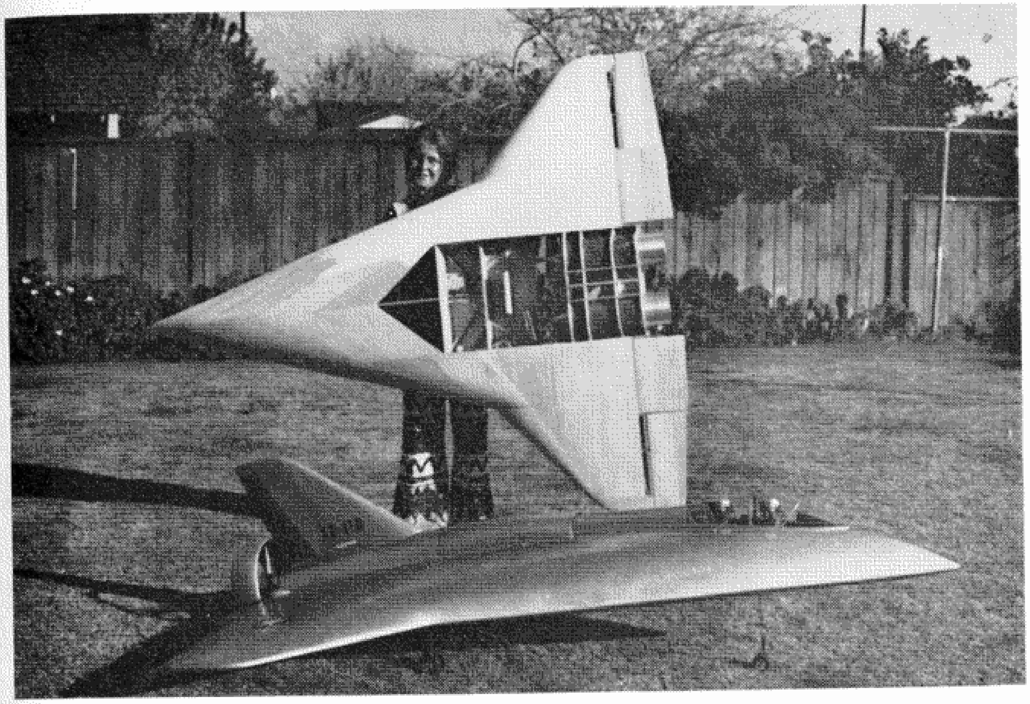




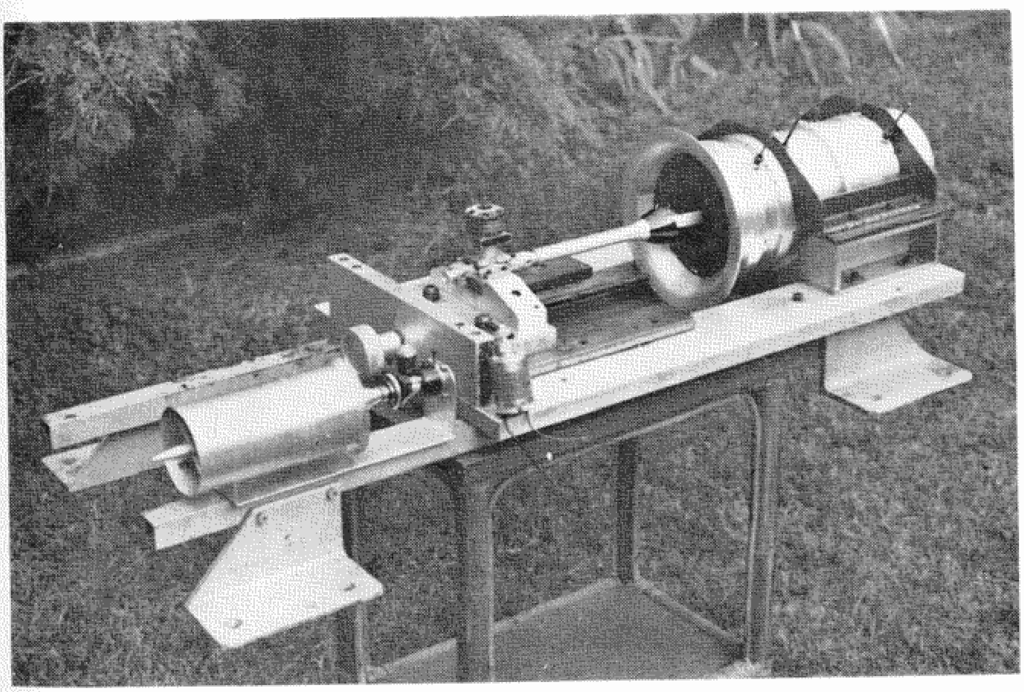
SEAGULL 44 in. Span. 37 in. Long. 4 lb. 2·6 sq. ft

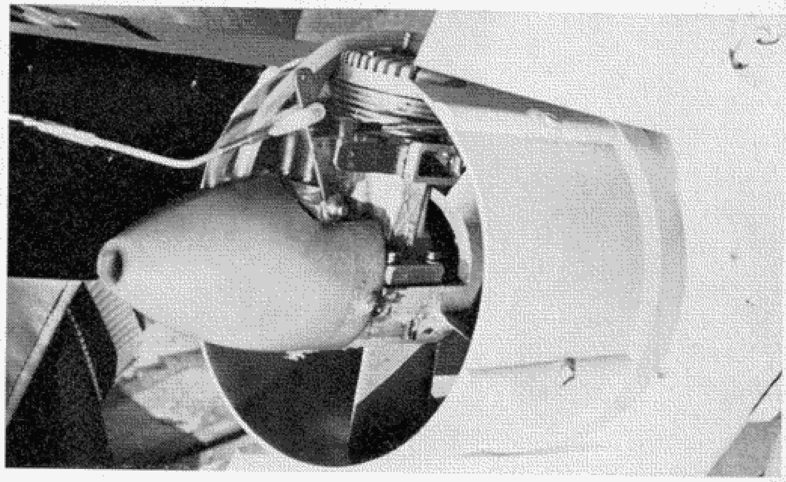
Cox TD ·010 powered C/L Mini-Delta with Rotorduct 100, span 11½ in., length 13 in. flies on 22 ft. lines up to 60 m.p.h. held by instrument read-out for Aero Marine Research ducted fan test rig in California. Ducts in foreground are for ·049 and ·40 engines developed by Cdr. W. Benson.



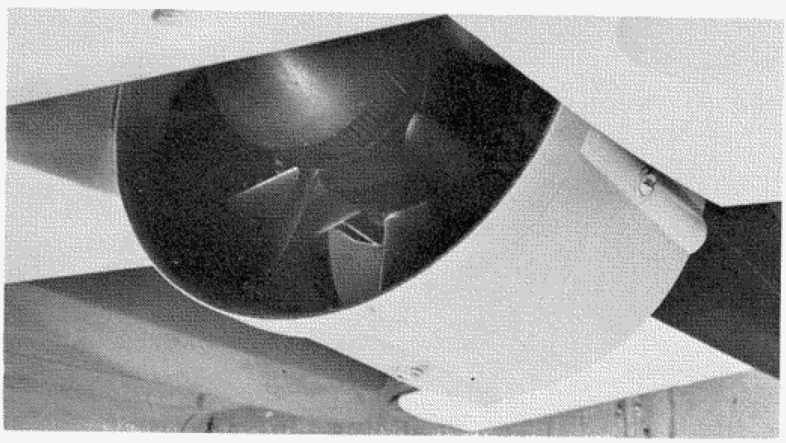


Above, the XD 110B with twin internal Rotorducts for ·40 to ·71 size engines, claims 22 lb. total thrust, and on ground, the XD 110A with an external duct, driven by twin cylinder ·80 unit (see p. 41). Below, test frame for Rotorduct with 11 lb. thrust, K & B 40 engine, Duct length is 12 in., weight 8½ ounces. In foreground is the ·049 Rotorduct. Production units will become available during 1975

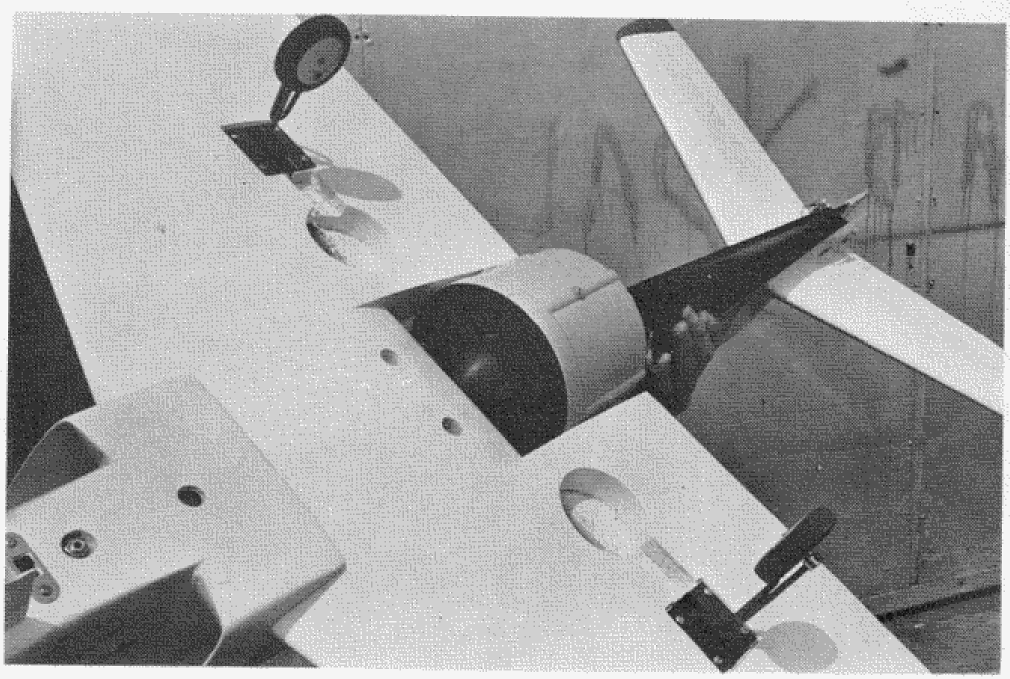


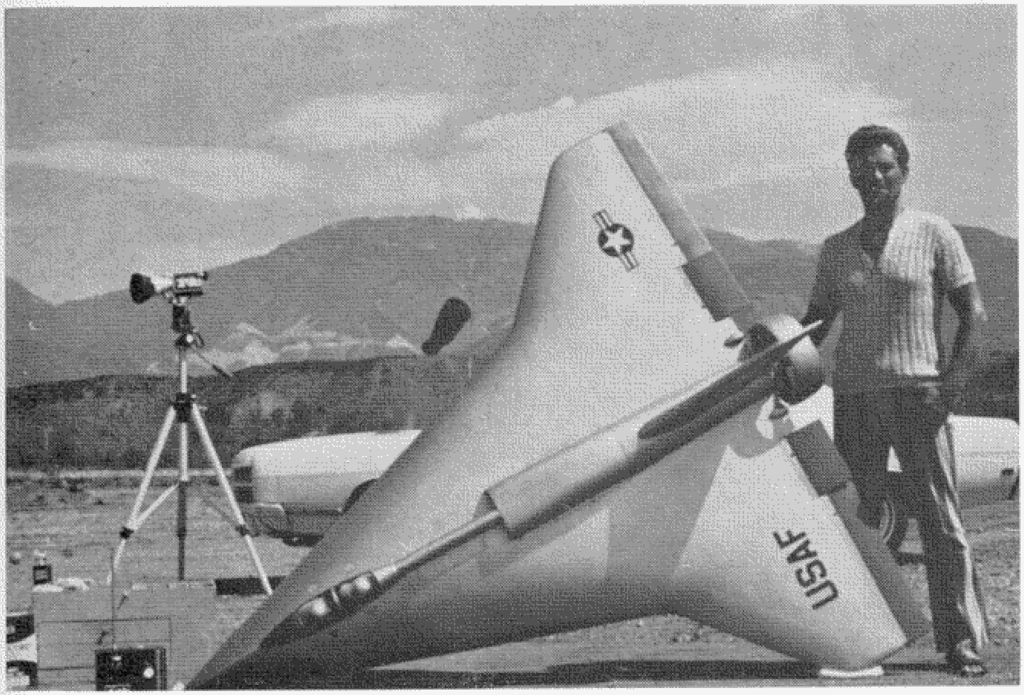


Rear, underside view of Turb-Ax I duct in "Sun-downer" shows throttle and carrier deck exhaust slide control on K & B 40. See page 27.

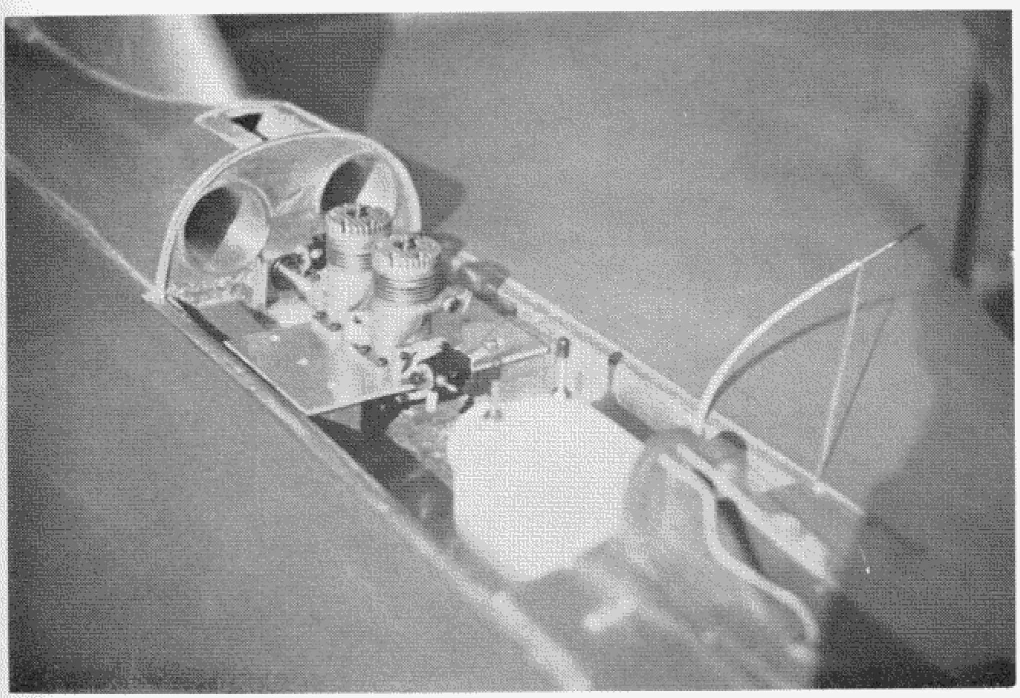


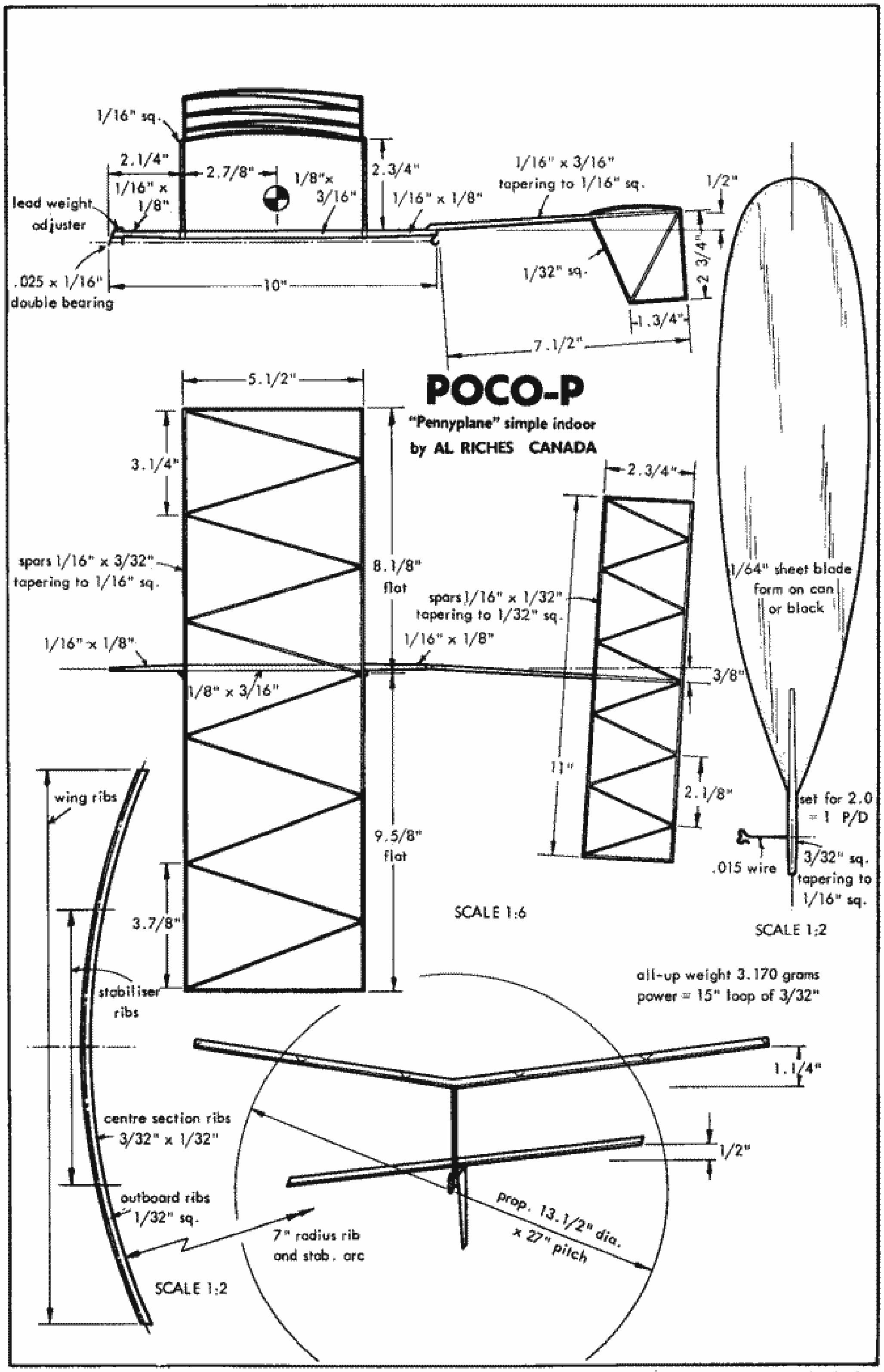
Front close up shows fibre filled nylon fan, ahead of cast alloy stator and engine mount Whole seen below, note short duct. Made by J.J. Scozzi Inc., Glen Echo, Maryland. Cost less engine, $70. Introduced to U.S. model trade July 1974 as a clip-on power unit, for ·40 size engines.



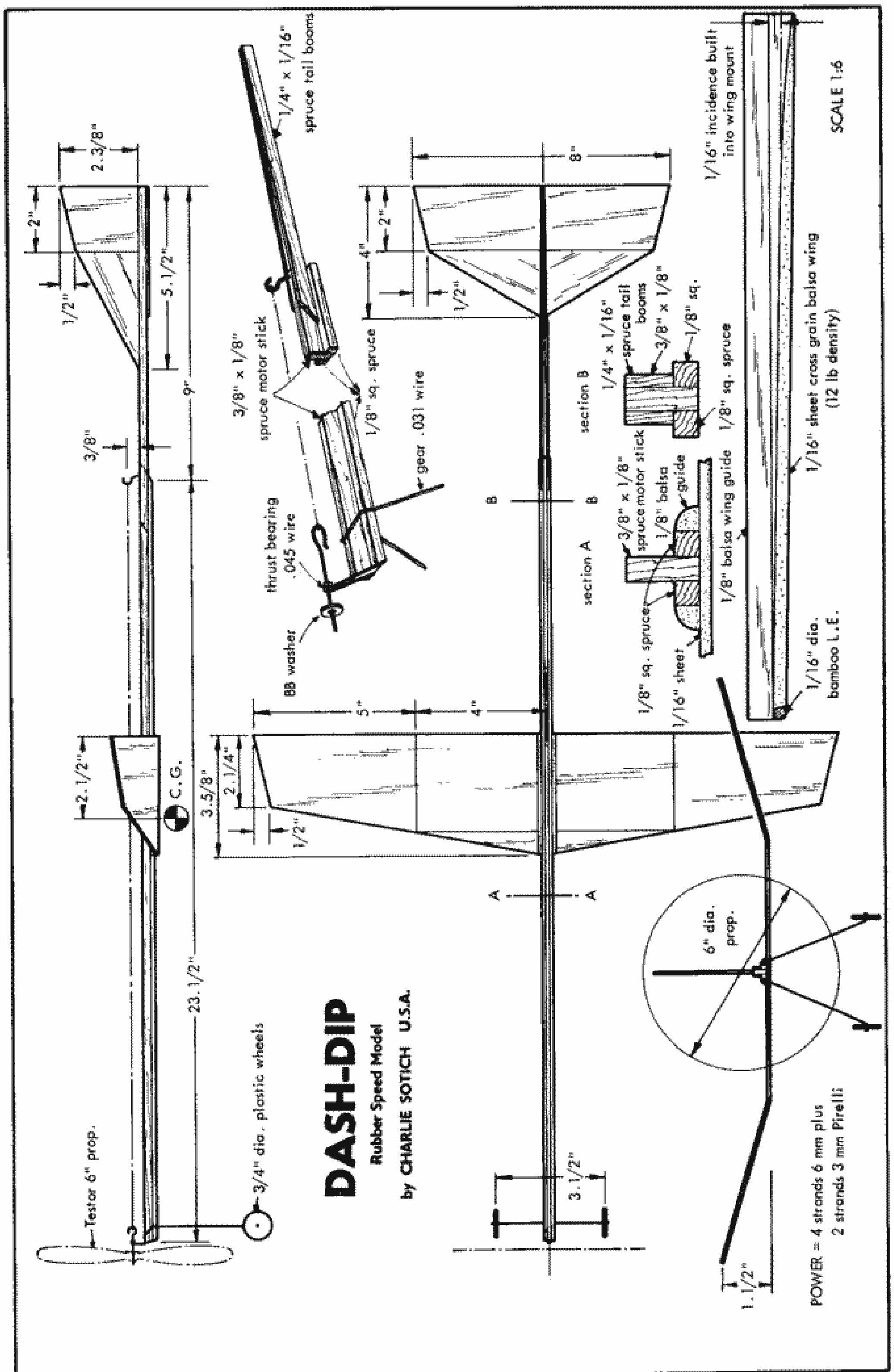


Cdr. W. Benson at Mojave desert test site for his R/C XD 110A which has recorded flight speeds up to 262 m.p.h. Power unit close up (below) is a combo of FR & RR K & B 40 making an alternate firing twin, driving long shaft to external fan in exterior duct at trailing edge. Units being developed for release at trade shows in 1975.

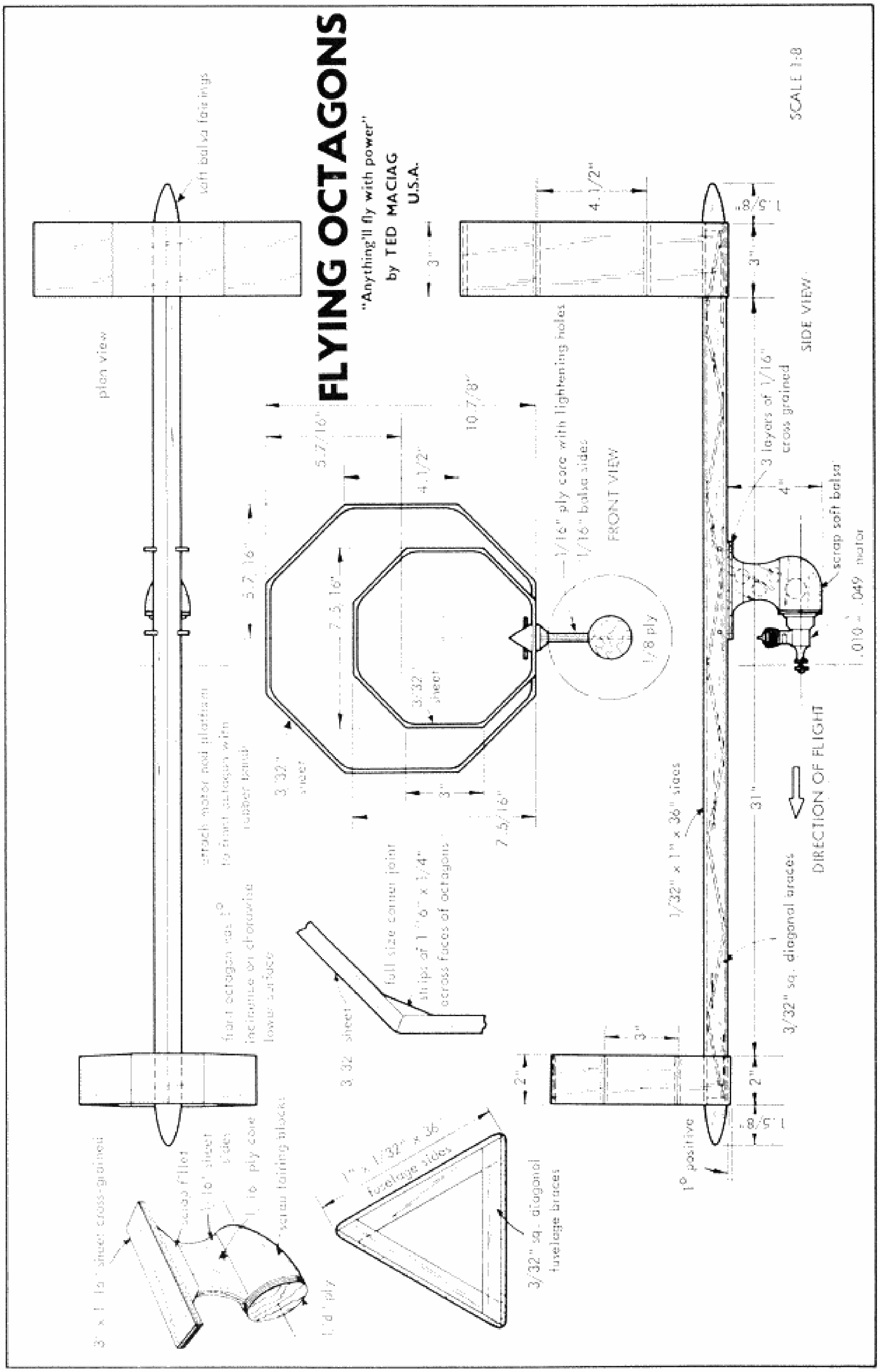




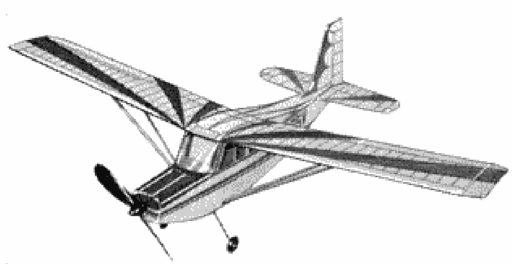
VANCOUVER G.M.C. CANADA

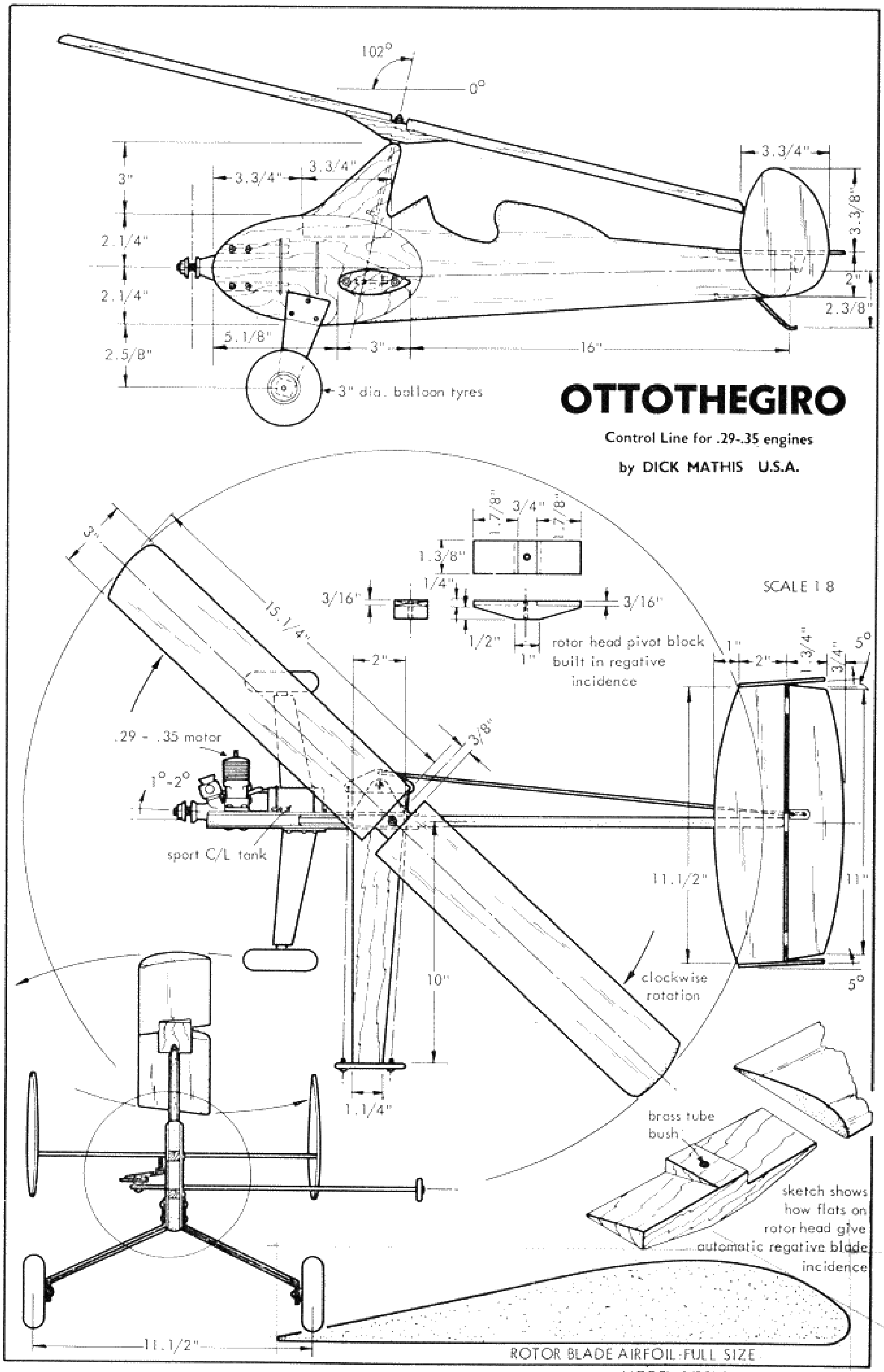


WILLAMETTE PATTER U.S.A.

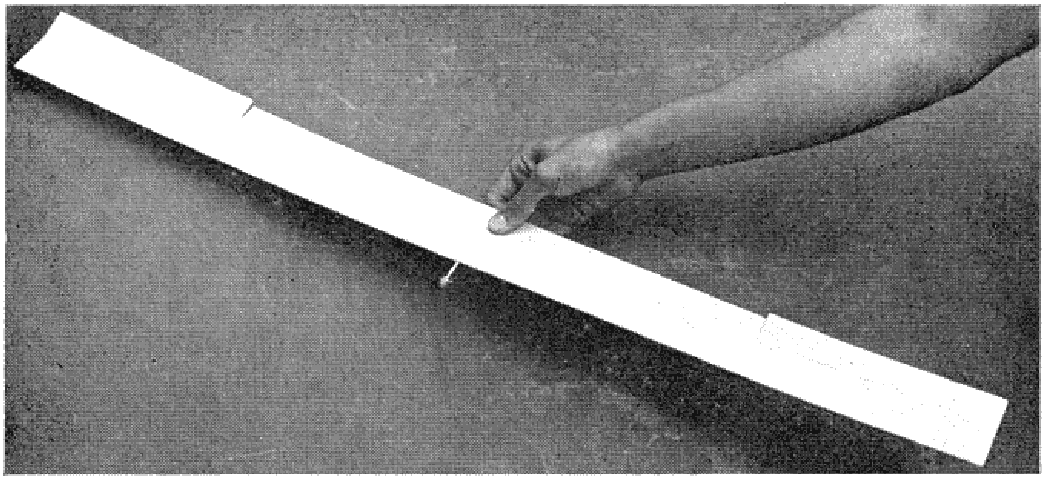


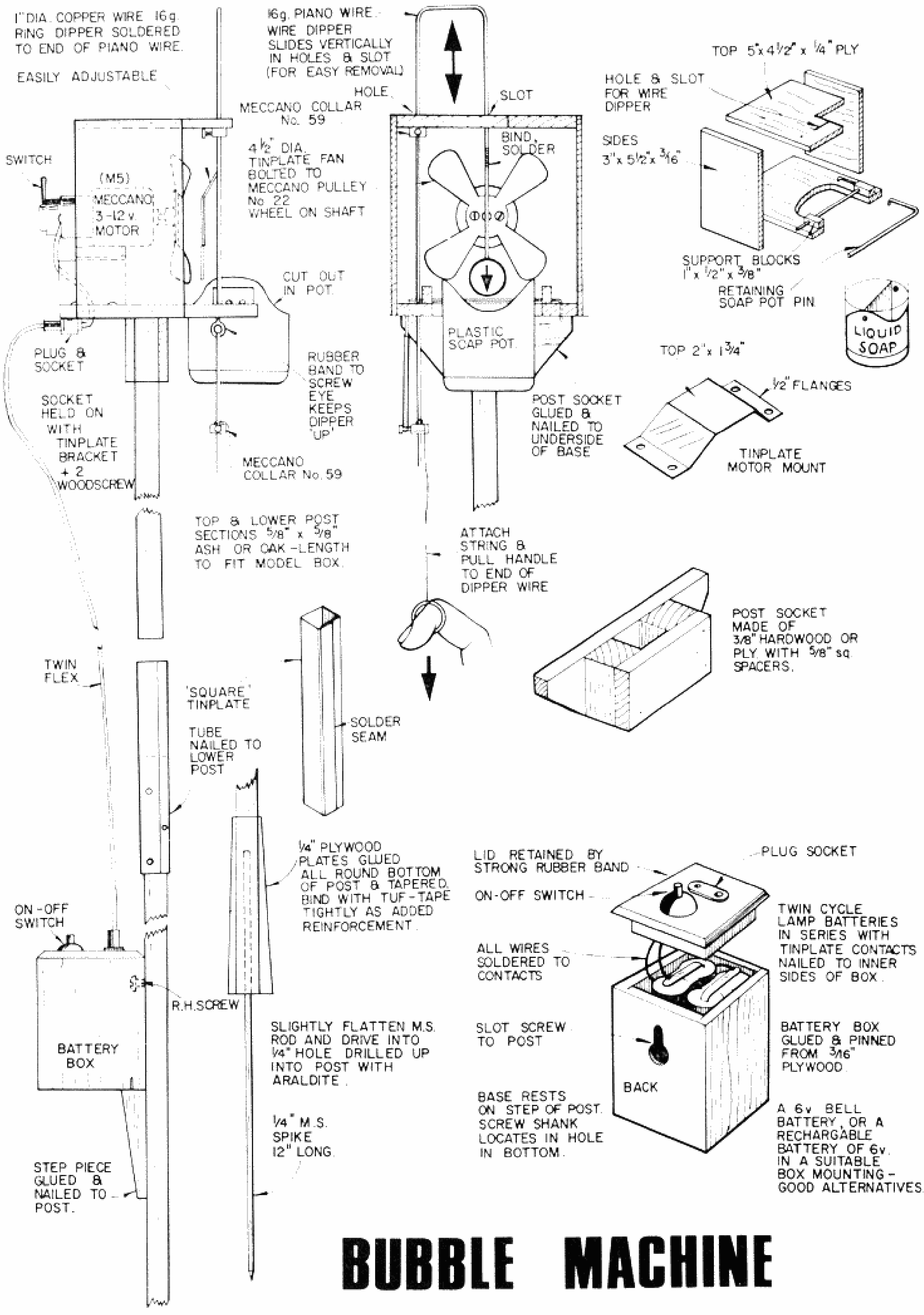
MODEL BUILDER U.S.A.





MODEL AIRPLANE NEWS U.S.A.





BUBBLE MACHINE

Search out those Thermals with the help of Ron Coleman's "In a Suitcase"

BUBBLE MACHINE

Piers Coleman operating the machine on Cleeve Common, Cheltenham. Fan can be seen revolving—unfortunately bubbles emitted cannot be seen against sky.

"*Come on, Dad, let's have that bubble machine!*" insisted my son Piers. For three weeks before the Coupe D'Hiver contest he had been on about it.

"*If . . . and it's a big if—if I get time to do it,*" I replied. In the event, between us, the thing was done. The post, or "fishing rod", in two sections, was tied with string to the insides of the model box. The machine head was in the suitcase, as we all flew out from Gatwick in the BAC111 for the big event. Sunday, 25th February was at hand, and I wondered if this extra thing had been worth the effort. It was enough, to deal with the models.

On the airfield at Le Plessis Belleville, the bubble machine proved to be very successful. Many competitors had the use of it throughout the day and it helped to score some max. flights. Many Frenchmen were intrigued by it, and could be observed giving the works a close scrutiny. Monsieur Bayet, the contest originator, photographed the apparatus, so perhaps it may be seen in *Modele Reduit d'Avion*? We forgot to ask if bubble machines are much used in France—they did seem to be interested to learn that this whole contraption is relatively light in weight, and can be packed into a suitcase; ideal for foreign travel, especially by air.

Post

The post which carries the machine as high as possible in the air, should be in sections of a length to fit the suitcase and/or model box. It is best to have as few lengths as possible, as long as possible, and there is a limit to the height which can be achieved in sections before the post becomes too flexible and unsteady. Probably three lengths of about 4 ft. is the optimum. We used two pieces which just fitted our 42-in. model box. $\frac{5}{8}$-in. × $\frac{5}{8}$-in. ash is best for the sections but any straight-grained wood will do. If deal is used, avoid knots, and increase the size to $\frac{3}{4}$-in. × $\frac{3}{4}$-in. Make the joints with the aid of tinplate sockets, soldered at the seam and nailed to the lower sections. You should end up with a "fishing rod" of two or three pieces all of them the same length. Note that the lowest section length is inclusive of the 12-in. × $\frac{1}{8}$-in. mild steel spike which is stuck in the ground when in use.

Box Frame

The apparatus is contained within a box of plywood. Cascamite glue and panel pin the pieces together. Reinforce the interior angles with $\frac{3}{8}$-in. square fillets (plane off the inner corner at 45°) if a stronger job is needed. Note the deep cut-out forming a Y-shape, in the base piece to allow the plastic soap pot to fit in, and swing on its 16-g. piano wire support pin. The pin penetrates the two 1-in. × $\frac{1}{2}$-in. × $\frac{3}{8}$-in. blocks glued and nailed to each prong of the Y-piece.

Motor

A Meccano M5 3–12 v. geared motor was used after discarding a lighter, less powerful Japanese 4 v. model boat motor. It is well worth experimenting to see whatever motor can be pressed to serve. The Meccano motor is rather expensive and was used because Piers already had it. The top gear of 6 is used.

Adapt the tin-plate motor mount to suit the motor to be used and fix with small wood screws to the base and Meccano or other small bolts to the motor. Design the mounting to offer the least restriction to the airflow.

Fan

Cut out a $4\frac{1}{2}$-in. diameter four-blade fan from tinplate or 20-g. aluminium. Drill a No. 22 Meccano pulley wheel to take two bolts; bolt the fan to the pulley wheel, and mount on the M5 motor shaft.

Dipper

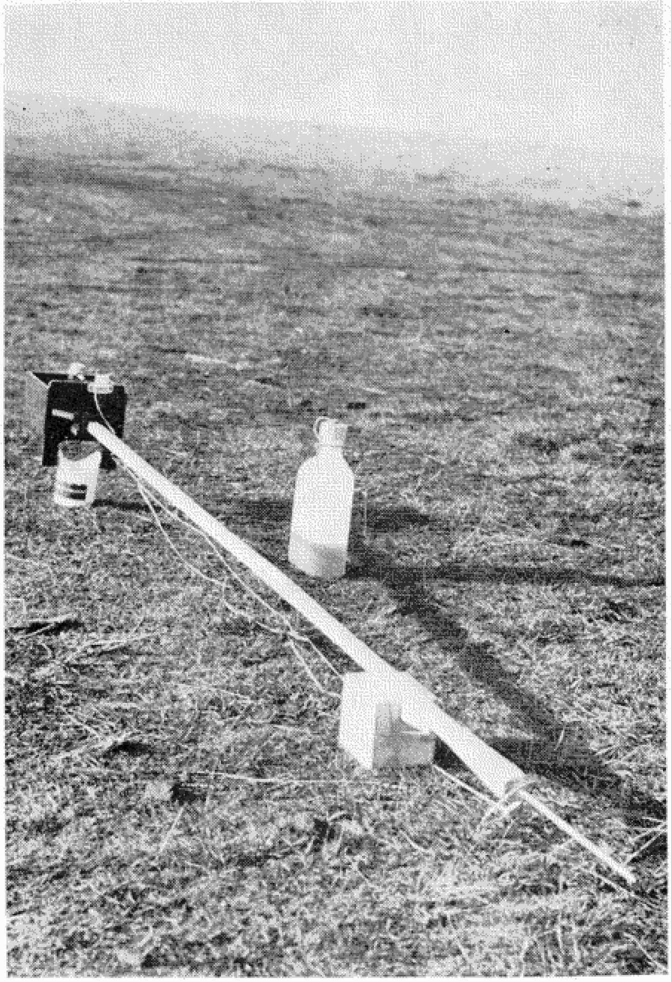
The frame is bent up from 16-g. piano wire. The dipper ring, 1-in. diameter, is made from 16-g. copper wire and soldered (bind with fuse wire) to the short end of the dipper frame. The copper wire allows of easy adjustment of the ring to the most effective position (about $\frac{1}{2}$-in. in front of the fan) to dip in the pot, and produce a stream of bubbles.

Meccano collars No. 59 (with long set screws) are used to stop the dipper frame at its upper limit and to secure the tension rubber band and pull string at the lower end.

Battery Box

Made from 4-mm plywood glued and pinned with tinplate contacts nailed inside to join two cycle-lamp batteries in series to provide 6 volts. It is not essential to make up a battery box—the two batteries could be held on the post step with strong rubber bands, with the flex attached by crocodile clips (dispense

Showing how the soap pot keeps its level position as the machine is laid forwards on to the ground. The pull string with wire ring can be seen looped around the steel spike. Liquid soap in bottle. Plug and socket with flex wire to be seen on bottom of box platform, at top of post.

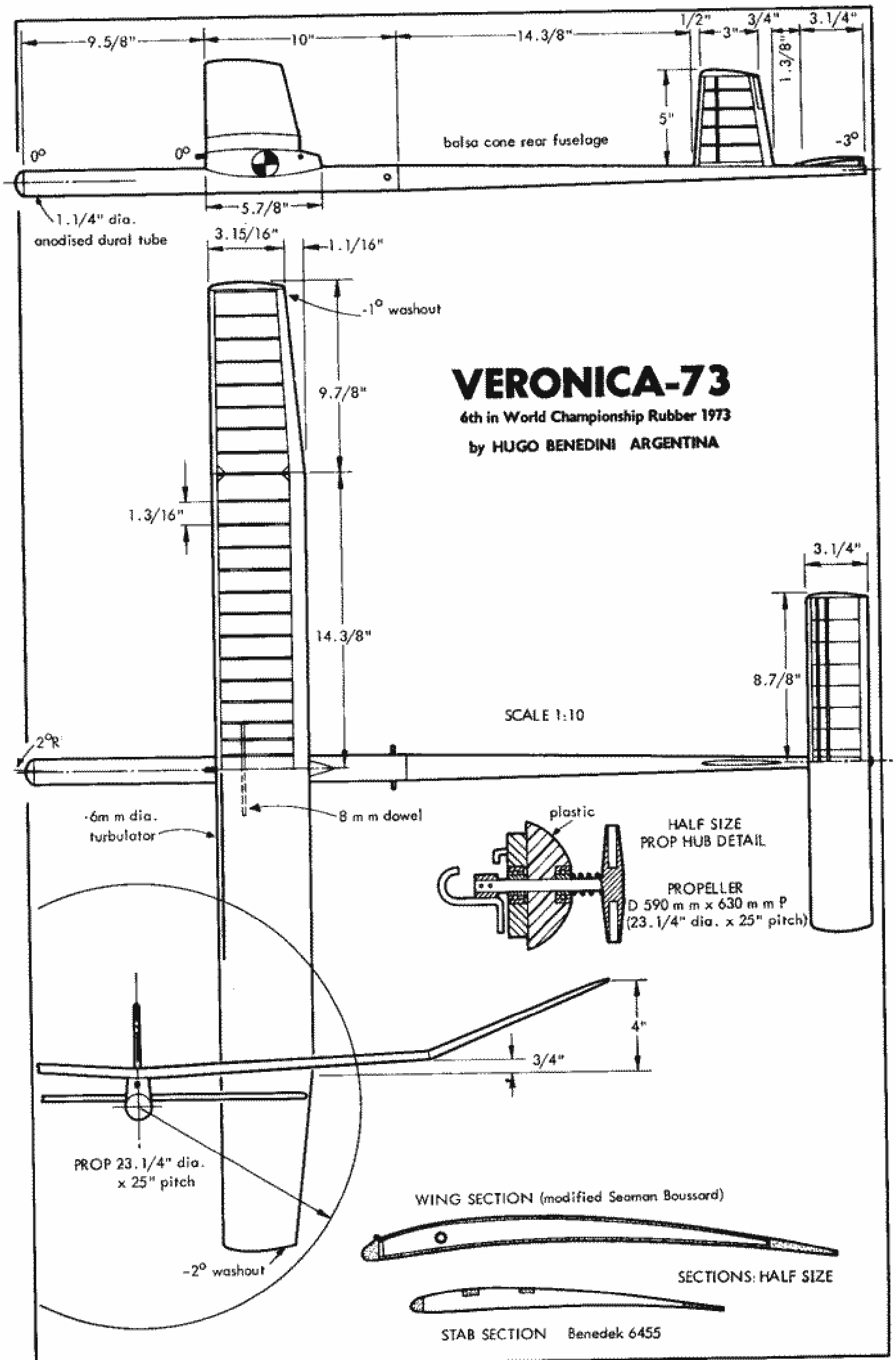


with the switch ?). A rechargeable lightweight battery is a good idea, or a wet battery if the machine is not to be carried about the flying field very much.

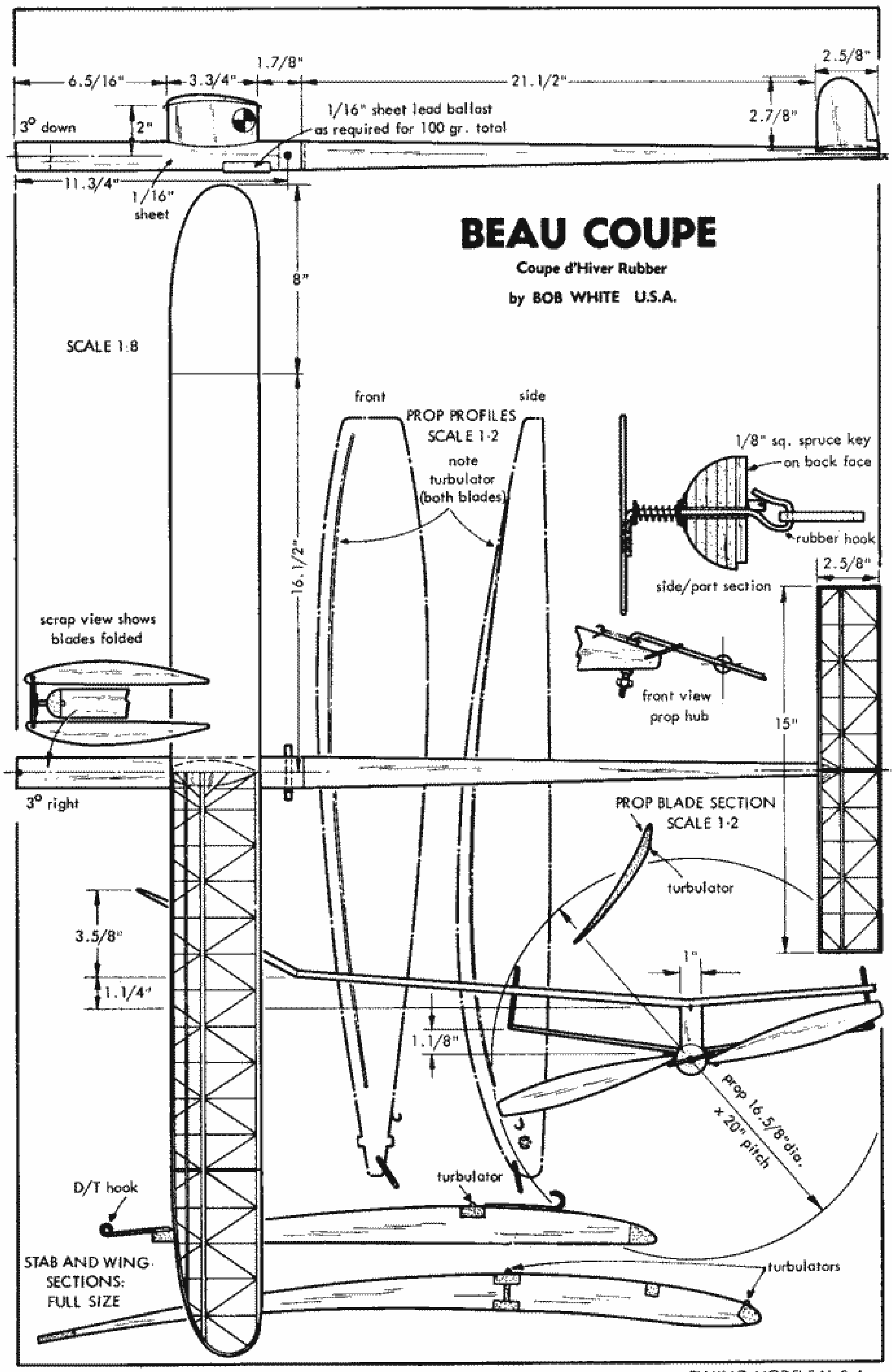
Remember to lower the machine from its high operating position, directly forwards, never sideways. The soap pot will swing forwards, always keeping level. It cannot swing to the side—you can easily be drenched in liquid soap! Well, now you have the machine—it isn't necessary to "foam" about that contest—just bubble!

Engine equivalents

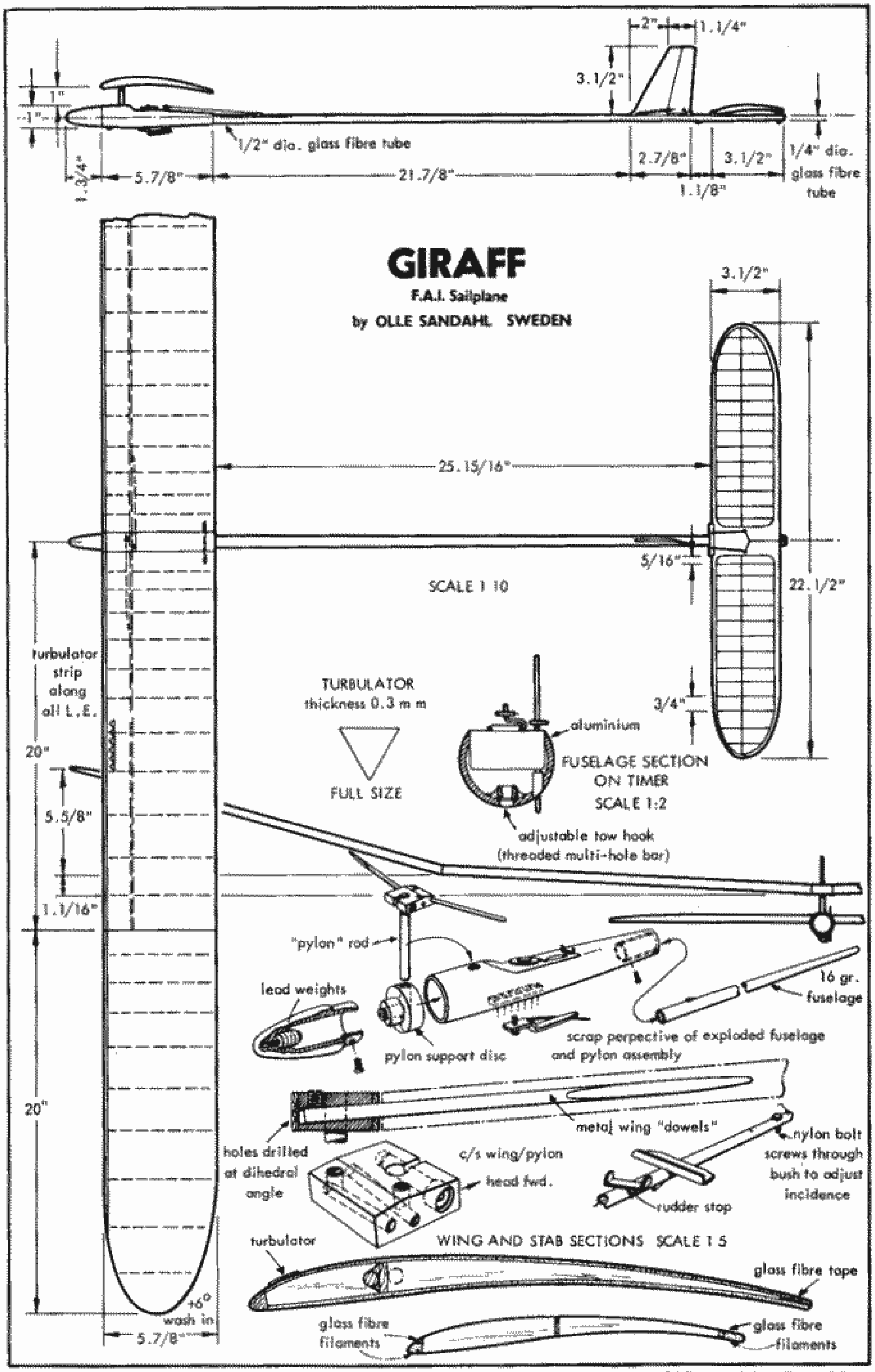
·10 cu. in. = 1·6387064 cc	1·0 cc = ·0610237 cu. in.
·20 cu. in. = 3·2774 cc	2·0 cc = ·1220 cu. in.
·30 cu. in. = 4·9161 cc	3·0 cc = ·1831 cu. in.
·50 cu. in. = 6·5548 cc	4·0 cc = ·2441 cu. in.
·60 cu. in. = 9·8322 cc	5·0 cc = ·3051 cu. in.
·70 cu. in. = 1·4709 cc	6·0 cc = ·3661 cu. in.
·80 cu. in. = 13·1096 cc	7·0 cc = ·4272 cu. in.
·90 cu. in. = 14·7483 cc	8·0 cc = ·5492 cu. in.



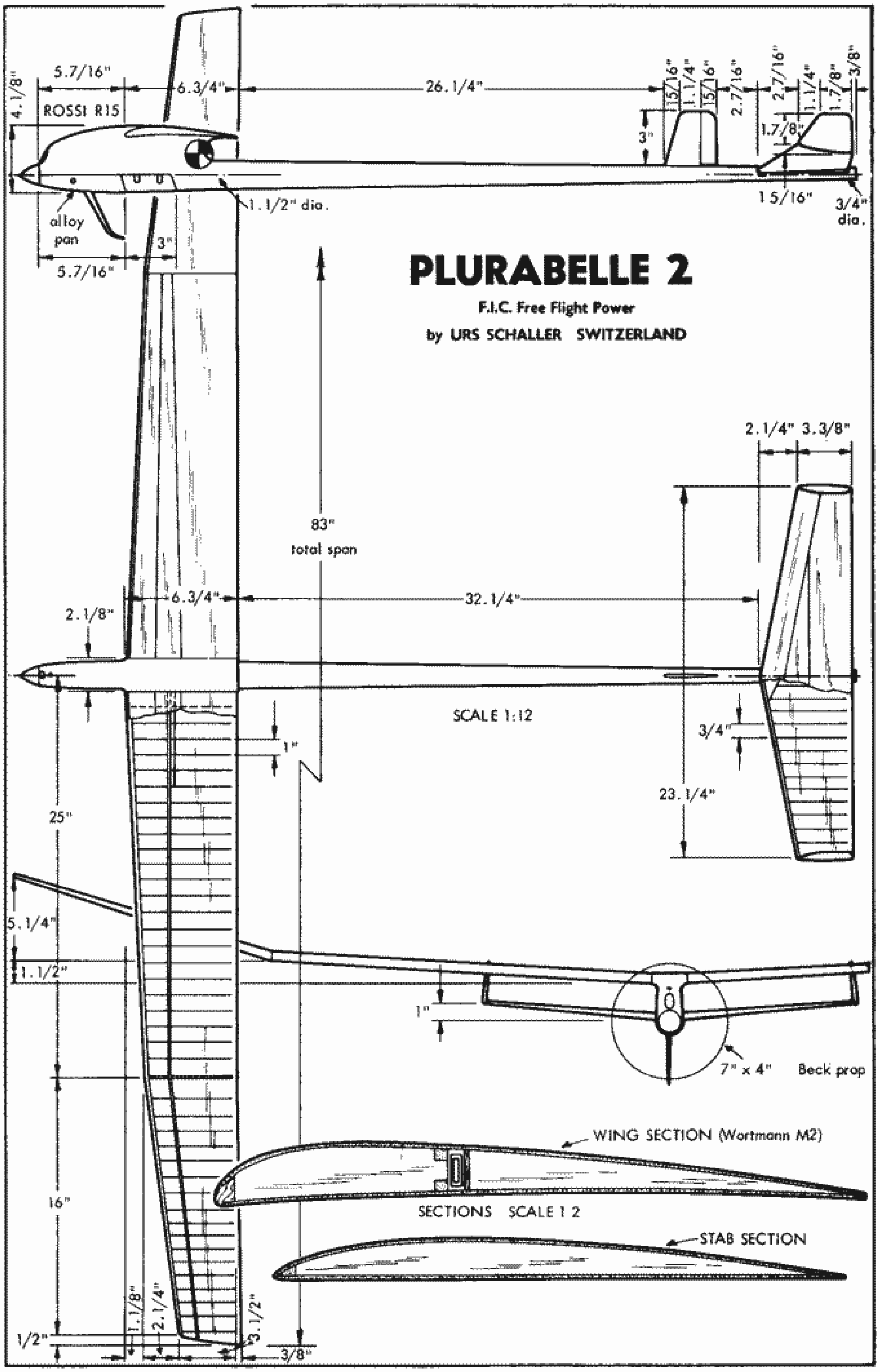
RIO DE LA PLATA NEWSLETTER



FLYING MODELS U.S.A.



MODELLFLYGGNYT SWEDEN



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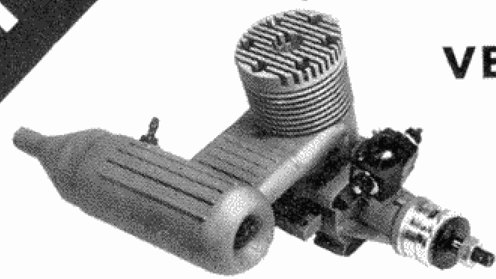
Presenting . . .

VECO "Europe Series" engines

with CONTROLLABLE POWER and highest standards quality and manufacture



VECO 61 R/C Europe Series

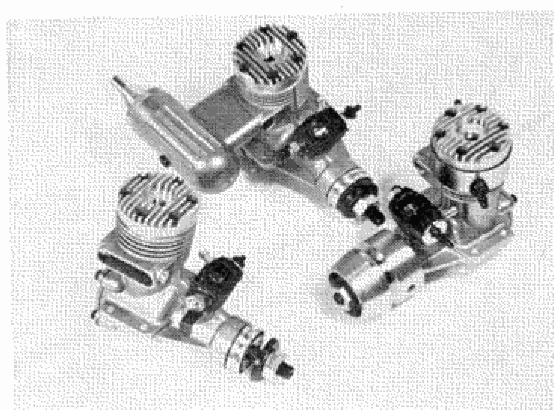
Enormous power—superb throttle characteristics with Perry Carb.

Aero R/C motor	**£27.95**
Marine R/C	**£31.75**
Muffler	**£4.00**

VECO 19 Europe Series

A new version of this popular sport power plant available in four different types

Aero	**£11.10**
Aero R/C	**£13.35**
Marine R/C	**£18.75**
R/C Car	**£14.20**
Muffler	**£1.95**



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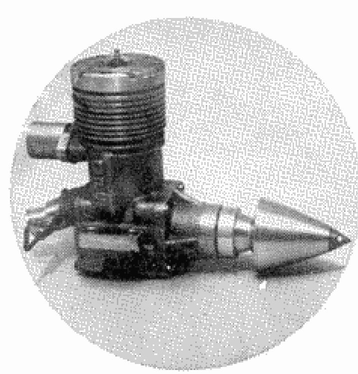

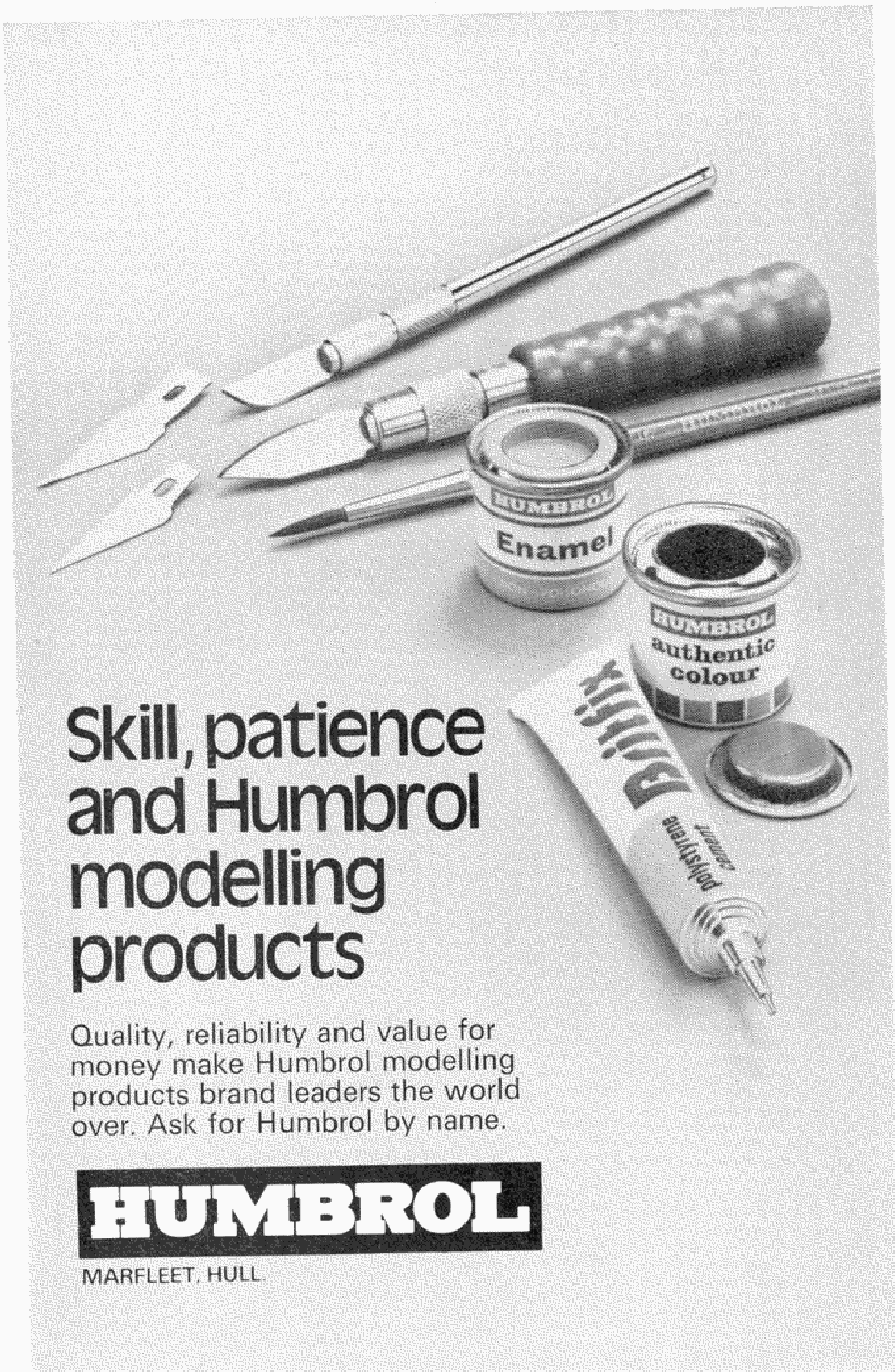
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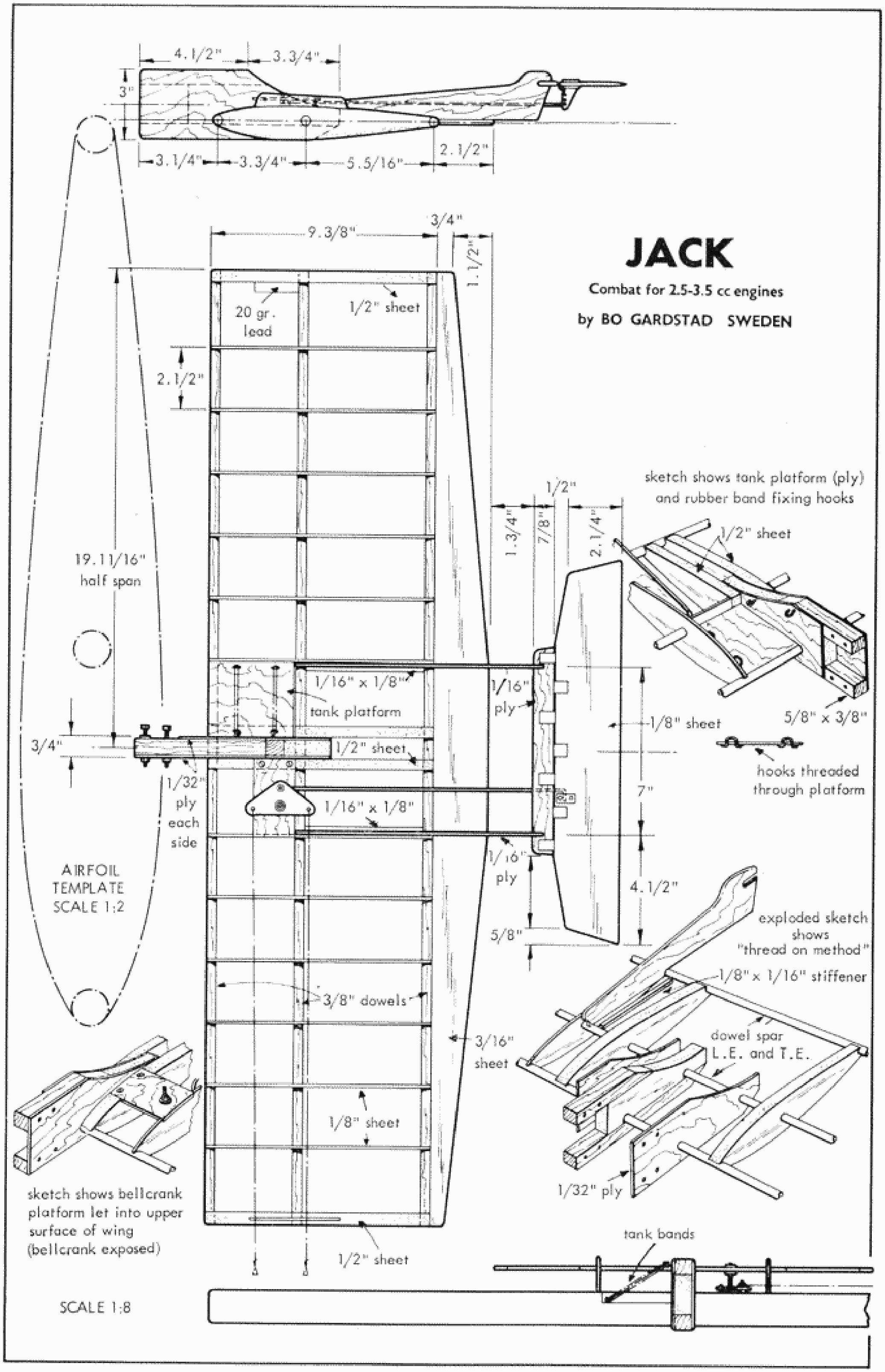
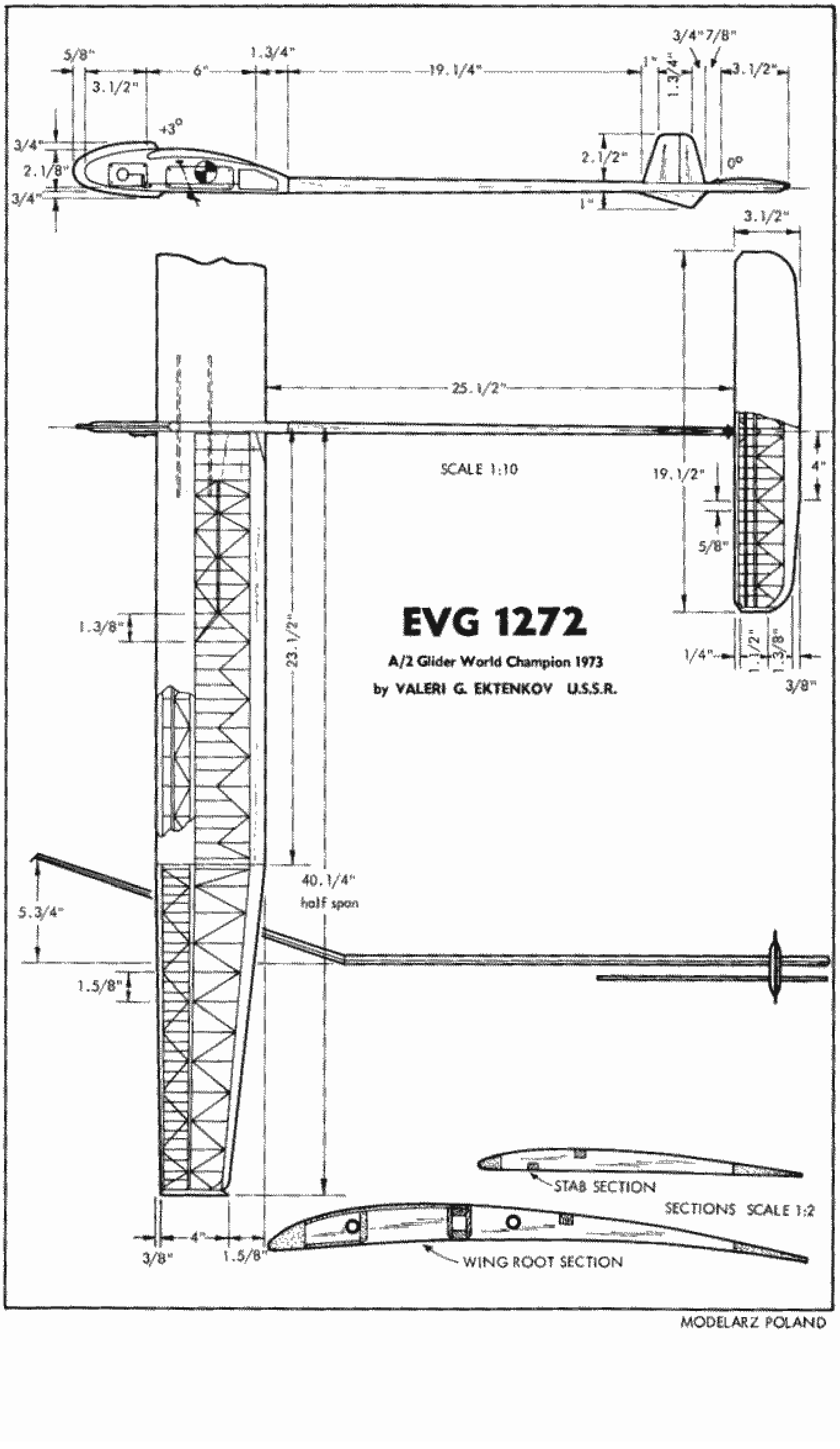
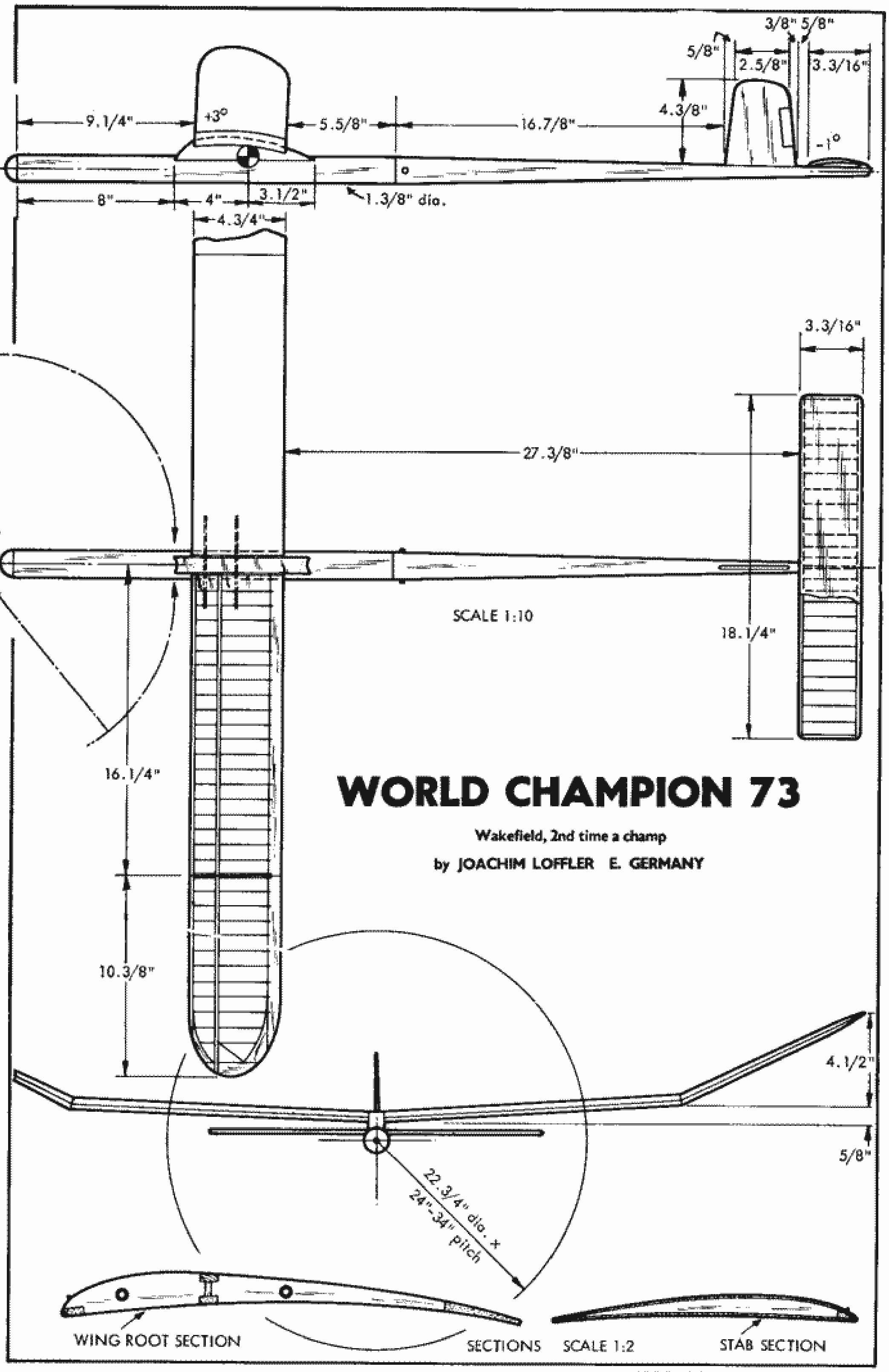


HOBBY SWEDEN



MODELARZ POLAND



WORLD CHAMPION 73

Wakefield, 2nd time a champ

by JOACHIM LOFFLER E. GERMANY

MODELLBAUHEUTE E. GERMANY

FORTY YEARS ON . . .

A distinguished group of pioneers in the field of American model aviation met in New York on April 19th, 1974 to honour Charles Hampson Grant, one of the most influential of authorities on model aerodynamics and flying.

The spirited Mr. Grant, now 80 years old, had come for a visit from his home in Vermont.

Nathan Polk of Polk's Model Craft Hobbies, Inc., was responsible for bringing this group together and he opened the luncheon with a tribute to all who attended.

"*It is dedication to and stimulation of interests in the growth of model aviation that brings us together*," he noted. "*You have played a vital part in aviation in this country. Our lives have been touched by Charles Grant*." And to Mr. Grant "*Thanks for the opportunity of knowing you*."

In reply Charles Grant said "*You are the root of the whole model aeroplane industry, dedicated to the truth and to the service of people. The pioneers started something because they believed in something. Aviation is adding one detail to another.*

"*There's a Trinity in everything*," he explained. "*For us, it is analysis, memory and putting things together right*."

"*Looking to the future*," he told his audience, "*you've got to come along with a new concept to rejuvenate the model airplane industry. You are in a critical moment in the economy and politics, in a new depression*."

"*Young people are fed up with the people in the universities. We have to get the 'stuffed shirts' out of teaching and get them out to see what life is all about*."

Mr. Grant had played a great part in interesting youth in model aviation when in the early 1920's he and his wife, Lillian, established a boy's summer camp in Peru, Vermont, that specialised in teaching model aircraft design and practice.

While he was editor of *Model Airplane News*, 1932–1943, he encouraged youths to start flying clubs in their towns.

At the age of 13 Mr. Grant became acquainted with model aviation and

Group photo of the U.S. Pioneers, meeting to honour C. H. Grant. Seated, l. to r.: Joe Raspante, Joe Rovel, Walter Caddell, Charles Grant, Dick Robbins, Eddy Beshar, Albin Zaic, Ben Shereshaw. Second row, l. to r.: Nathan Polk, Ed Miller, Bob Mercer, Don McGovern, Frank Ehling, Geoff Wheeler, Jane Goldsmith, Maxwell Bassett, Milt Schulman, Leo Weiss. Back row, l. to r.: Gordon Light, Bill Effinger, Leo Shulman, Bill Brown, Dave Brown, Bernie Paul, Dick Bennett, Lewis Polk, Tom Murn, Art Schroeder, Walter Musciano, John Zaic, Bill Tyler, Fred Polk.

joined a group of model flyers in New York. A year later he started his own flying group in Elizabeth, N.J., his birthplace.

For five years he experimented with gliders and building flying models, not as an entertaining hobby, but for the purpose of research into the laws of aerodynamics.

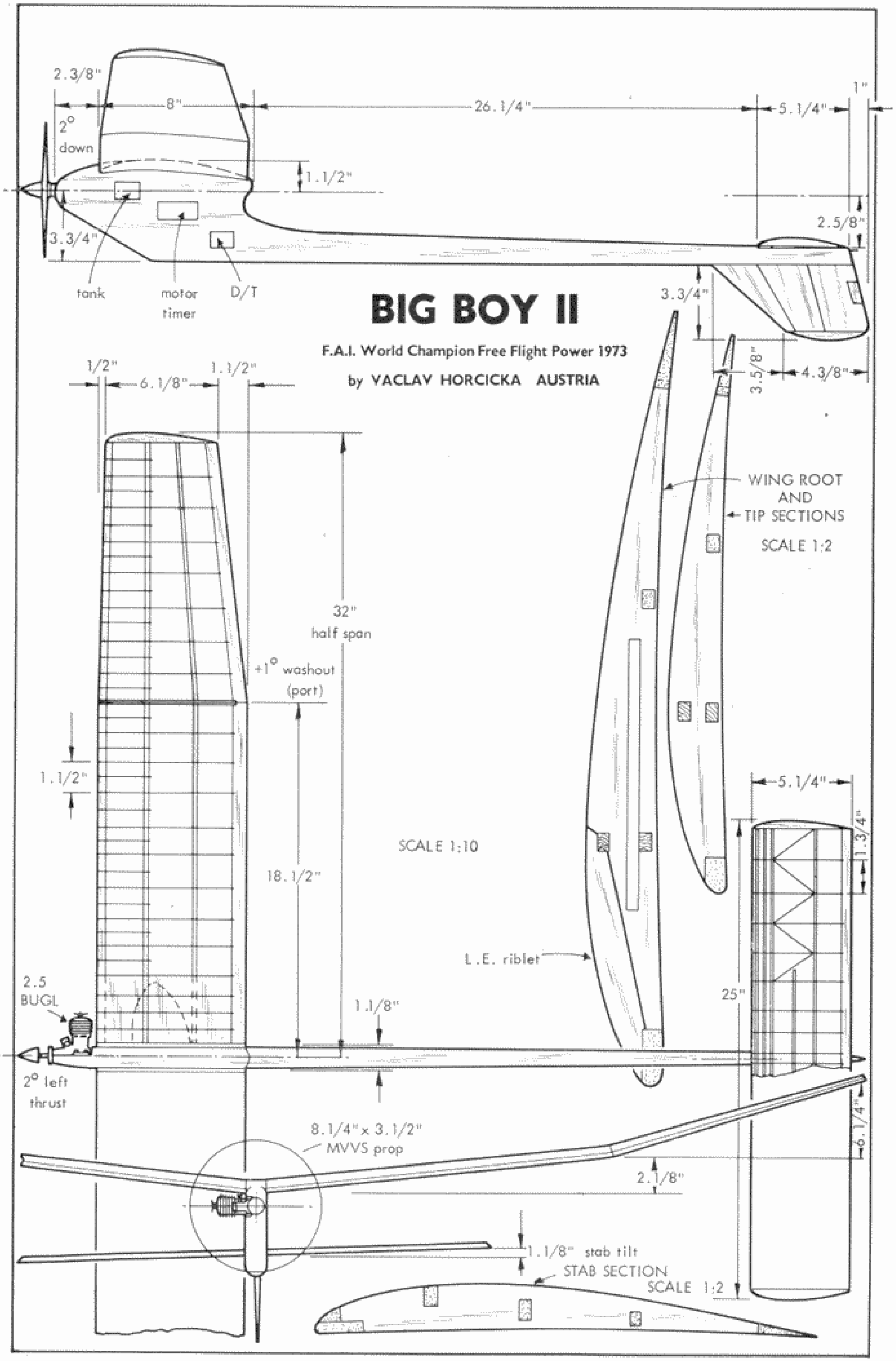
With Joseph Kovel, a former student at his summer camp, he developed the successful K-G, which became a renowned type of powered plane that was subsequently built in nearly every country of the world; hence its nickname "*the pilotless airplane that flew around the world*".

In developing the K-G, Mr. Grant brought forth what he called the "*Law of Rotational Stability*": the displacement of axis (the axis of longitudinal rotation) should be kept positive (sloping upward) relative to the line of flight in order to make the plane roll with the nose up instead of down.

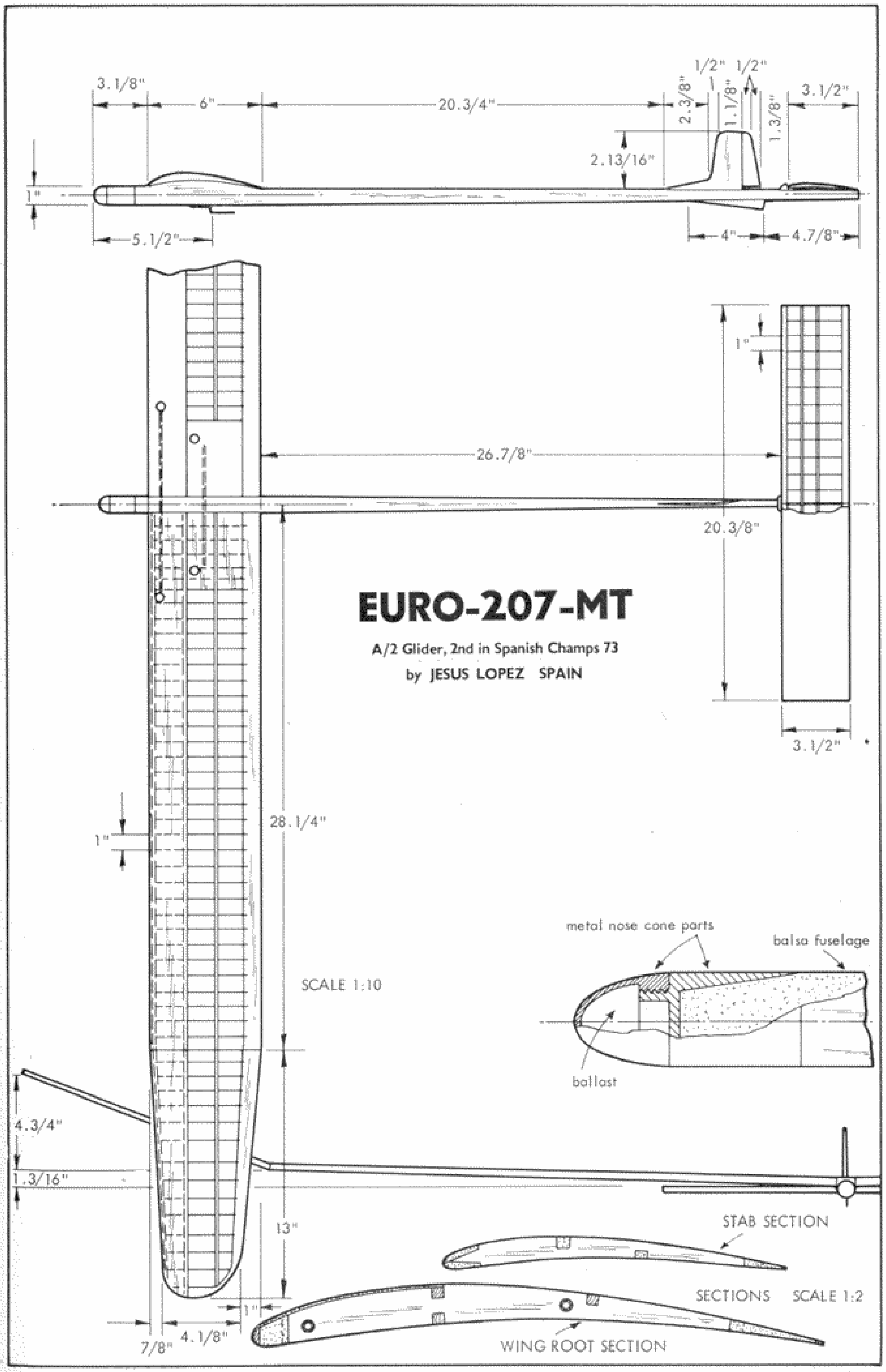
He wrote his basic textbook on model aerodynamics, *Model Airplane Design and Theory of Flight*, published in 1941 and now to be republished in 1974.

Through the efforts of Mr. Grant and the staff of *Model Airplane News*, the International Gas Model Airplane Association was formed. It grew to 6,000 members and was accepted as the nucleus of the *Academy of Model Aerodynamics*, which is today the major voice of model aviation fans in the U.S.A.

Charles Grant, left, is discussing the republication of his book, *Model Airplane Design and Theory of Flight* with Nathan Polk, whom he described as "having held the U.S. model aviation industry together more than anyone else".



VARESE BULLETIN ITALY

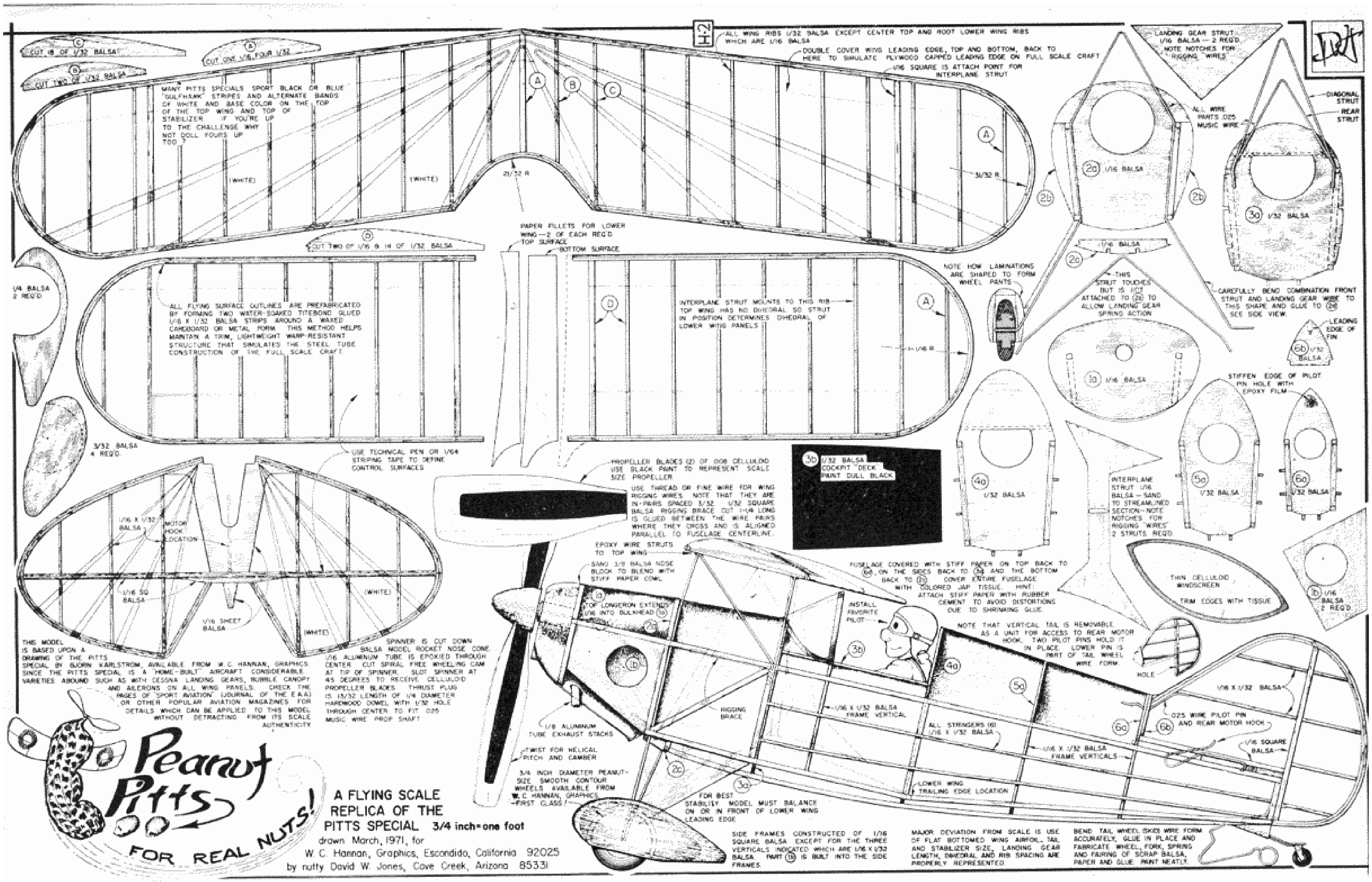


EURO-207-MT

A/2 Glider, 2nd in Spanish Champs 73

by JESUS LOPEZ SPAIN

AVION SPAIN


H-2
ALL WING RIBS 1/32 BALSA EXCEPT CENTER TOP AND ROOT LOWER WING RIBS WHICH ARE 1/16 BALSA
DOUBLE COVER WING LEADING EDGE, TOP AND BOTTOM, BACK TO HERE TO SIMULATE PLYWOOD CAPPED LEADING EDGE ON FULL SCALE CRAFT
1/16 SQUARE IS ATTACH POINT FOR INTERPLANE STRUT
CUT 18 OF 1/32 BALSA
CUT ONE 1/16, FOUR 1/32
CUT TWO OF 1/32 BALSA
MANY PITTS SPECIALS SPORT BLACK OR BLUE "GULFHAWK" STRIPES AND ALTERNATE BANDS OF WHITE AND BASE COLOR ON THE TOP OF THE TOP WING AND TOP OF STABILIZER. IF YOU'RE UP TO THE CHALLENGE WHY NOT DOLL YOURS UP TOO ?
(WHITE)
21/32 R
3 1/32 R
CUT TWO OF 1/16 & 14 OF 1/32 BALSA
PAPER FILLETS FOR LOWER WING—2 OF EACH REQ'D.
TOP SURFACE
BOTTOM SURFACE
1/4 BALSA 2 REQ'D.
ALL FLYING SURFACE OUTLINES ARE PREFABRICATED BY FORMING TWO WATER-SOAKED TITEBOND GLUED 1/16 X 1/32 BALSA STRIPS AROUND A WAXED CARDBOARD OR METAL FORM. THIS METHOD HELPS MAINTAIN A TRIM, LIGHTWEIGHT WARP-RESISTANT STRUCTURE THAT SIMULATES THE STEEL TUBE CONSTRUCTION OF THE FULL SCALE CRAFT.
INTERPLANE STRUT MOUNTS TO THIS RIB. TOP WING HAS NO DIHEDRAL SO STRUT IN POSITION DETERMINES DIHEDRAL OF LOWER WING PANELS.
3/32 BALSA 4 REQ'D.
USE TECHNICAL PEN OR 1/64 STRIPING TAPE TO DEFINE CONTROL SURFACES
PROPELLER BLADES (2) OF .008 CELLULOID. USE BLACK PAINT TO REPRESENT SCALE SIZE PROPELLER
USE THREAD OR FINE WIRE FOR WING RIGGING WIRES. NOTE THAT THEY ARE IN PAIRS SPACED 3/32. 1/32 SQUARE BALSA RIGGING BRACE CUT 1-1/4 LONG IS GLUED BETWEEN THE WIRE PAIRS WHERE THEY CROSS AND IS ALIGNED PARALLEL TO FUSELAGE CENTERLINE.
3b 1/32 BALSA COCKPIT DECK PAINT DULL BLACK
1/16 X 1/32 BALSA
MOTOR HOOK LOCATION
1/16 SQ BALSA
1/16 SHEET BALSA
THIS MODEL IS BASED UPON A DRAWING OF THE PITTS SPECIAL BY BJORN KARLSTROM, AVAILABLE FROM W. C. HANNAN, GRAPHICS. SINCE THE PITTS SPECIAL IS A "HOME-BUILT" AIRCRAFT CONSIDERABLE VARIETIES ABOUND SUCH AS WITH CESSNA LANDING GEARS, BUBBLE CANOPY AND AILERONS ON ALL WING PANELS. CHECK THE PAGES OF "SPORT AVIATION" (JOURNAL OF THE E.A.A.) OR OTHER POPULAR AVIATION MAGAZINES FOR DETAILS WHICH CAN BE APPLIED TO THIS MODEL WITHOUT DETRACTING FROM ITS SCALE AUTHENTICITY.
SPINNER IS CUT DOWN BALSA MODEL ROCKET NOSE CONE. 1/16 ALUMINUM TUBE IS EPOXIED THROUGH CENTER. CUT SPIRAL FREE WHEELING CAM AT TIP OF SPINNER. SLOT SPINNER AT 45 DEGREES TO RECEIVE CELLULOID PROPELLER BLADES. THRUST PLUG IS 13/32 LENGTH OF 1/4 DIAMETER HARDWOOD DOWEL WITH 1/32 HOLE THROUGH CENTER TO FIT .025 MUSIC WIRE PROP SHAFT.
EPOXY WIRE STRUTS TO TOP WING
SAND 3/8 BALSA NOSE BLOCK TO BLEND WITH STIFF PAPER COWL
TOP LONGERON EXTENDS 1/16 INTO BULKHEAD
1/8 ALUMINUM TUBE EXHAUST STACKS
TWIST FOR HELICAL PITCH AND CAMBER
3/4 INCH DIAMETER PEANUT-SIZE SMOOTH CONTOUR WHEELS AVAILABLE FROM W. C. HANNAN, GRAPHICS —FIRST CLASS !
RIGGING BRACE
1/16 X 1/32 BALSA FRAME VERTICAL
FOR BEST STABILITY MODEL MUST BALANCE ON OR IN FRONT OF LOWER WING LEADING EDGE
INSTALL FAVORITE PILOT
ALL STRINGERS (6) 1/16 X 1/32 BALSA
1/16 X 1/32 BALSA FRAME VERTICALS
LOWER WING TRAILING EDGE LOCATION
SIDE FRAMES CONSTRUCTED OF 1/16 SQUARE BALSA EXCEPT FOR THE THREE VERTICALS INDICATED WHICH ARE 1/16 X 1/32 BALSA. PART 1b IS BUILT INTO THE SIDE FRAMES.
MAJOR DEVIATION FROM SCALE IS USE OF FLAT BOTTOMED WING AIRFOIL. TAIL AND STABILIZER SIZE, LANDING GEAR LENGTH, DIHEDRAL AND RIB SPACING ARE PROPERLY REPRESENTED.
BEND TAIL WHEEL (SKID) WIRE FORM ACCURATELY, GLUE IN PLACE AND FABRICATE WHEEL, FORK, SPRING AND FAIRING OF SCRAP BALSA, PAPER AND GLUE. PAINT NEATLY.
FUSELAGE COVERED WITH STIFF PAPER ON TOP BACK TO 6a, ON THE SIDES BACK TO 5a AND THE BOTTOM BACK TO 2c. COVER ENTIRE FUSELAGE WITH COLORED JAP TISSUE. HINT: ATTACH STIFF PAPER WITH RUBBER CEMENT TO AVOID DISTORTIONS DUE TO SHRINKING GLUE.
NOTE THAT VERTICAL TAIL IS REMOVABLE AS A UNIT FOR ACCESS TO REAR MOTOR HOOK. TWO PILOT PINS HOLD IT IN PLACE. LOWER PIN IS PART OF TAIL WHEEL WIRE FORM.
HOLE
1/16 X 1/32 BALSA
.025 WIRE PILOT PIN AND REAR MOTOR HOOK
1/16 SQUARE BALSA
LANDING GEAR STRUT 1/16 BALSA — 2 REQ'D. NOTE NOTCHES FOR RIGGING "WIRES"
ALL WIRE PARTS .025 MUSIC WIRE
DIAGONAL STRUT
REAR STRUT
2a 1/16 BALSA
3a 1/32 BALSA
2c 1/16 BALSA
NOTE HOW LAMINATIONS ARE SHAPED TO FORM WHEEL PANTS
THIS STRUT TOUCHES BUT IS NOT ATTACHED TO 2c TO ALLOW LANDING GEAR SPRING ACTION
CAREFULLY BEND COMBINATION FRONT STRUT AND LANDING GEAR WIRE TO THIS SHAPE AND GLUE TO 2a. SEE SIDE VIEW.
LEADING EDGE OF FIN
6b 1/32 BALSA
1a 1/16 BALSA
STIFFEN EDGE OF PILOT PIN HOLE WITH EPOXY FILM
4a 1/32 BALSA
5a 1/32 BALSA
6a 1/32 BALSA
INTERPLANE STRUT 1/16 BALSA — SAND TO STREAMLINED SECTION — NOTE NOTCHES FOR RIGGING "WIRES" 2 STRUTS REQ'D.
THIN CELLULOID WINDSCREEN
TRIM EDGES WITH TISSUE
1b 1/16 BALSA 2 REQ'D.
Peanut Pitts
FOR REAL NUTS!
A FLYING SCALE REPLICA OF THE PITTS SPECIAL 3/4 inch = one foot
drawn March, 1971, for
W. C. Hannan, Graphics, Escondido, California 92025
by nutty David W. Jones, Cave Creek, Arizona 85331

Fokker V-45, complete with actual scale Peanut, made by Walt Mooney.

BACK TO THE STICKS

(the fun is still there)

By Bill Hannan

PEANUT SCALE HISTORY

BEFORE World War Two, models in the United States were marketed in "lines", arranged according to wing spans, rather than specific scale reductions. Thus, a given span model was usually in a given price range. Common groupings were 36 in., 24 in., 16 in. and 12 in. This smallest grouping was probably the most popular, since it was the least expensive, and the majority of the customers were youngsters of quite limited means.

Believe it or not, these "one-footers" could be obtained in kit form for as little as ten cents (Megow's were 9d. ($3\frac{3}{4}$p) in Britain), and this included the following:

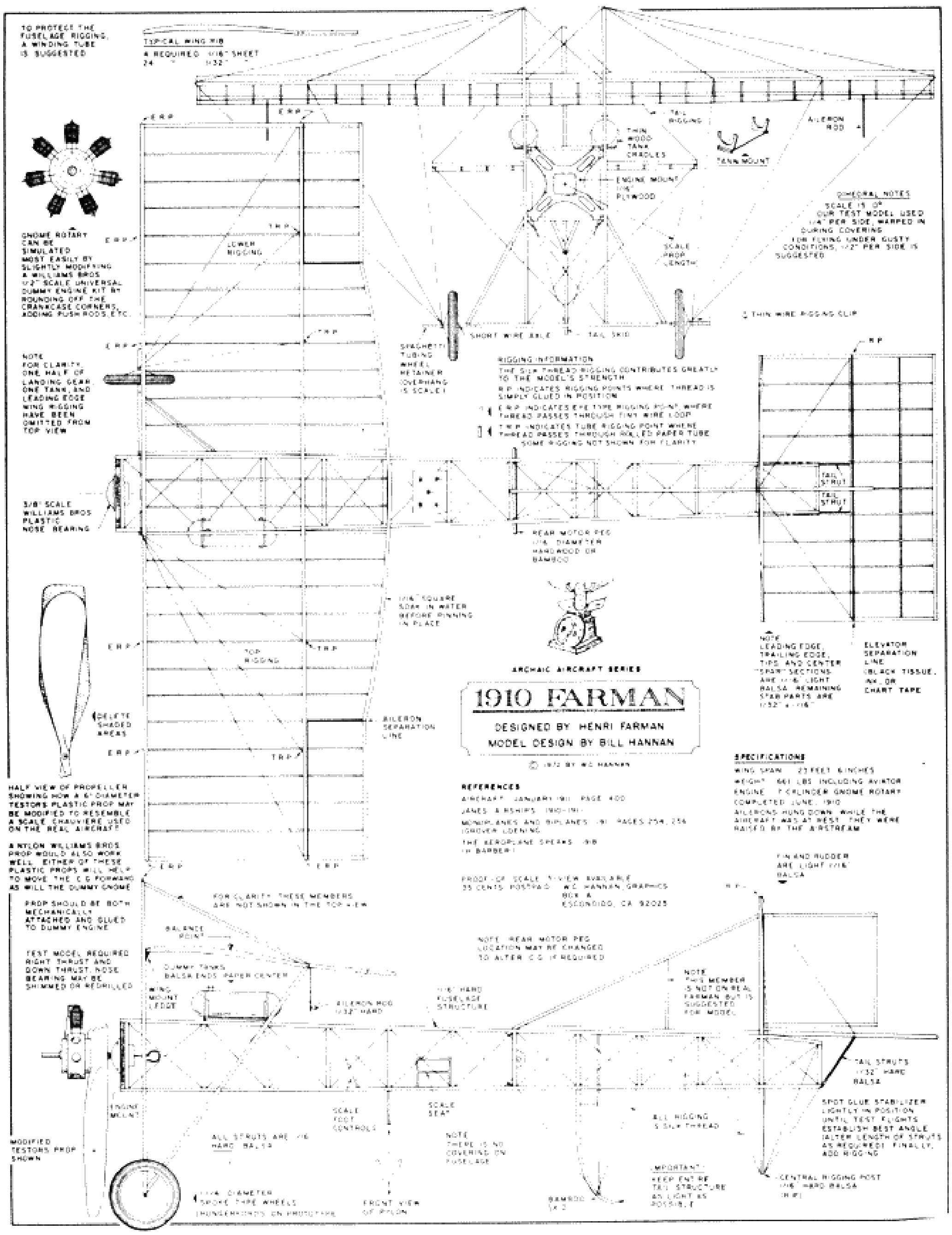
Full-size printed plan
Balsa stripwood
Printed sheet balsa
Machine cut balsa prop
Propeller hook
Brass thrust washers
Rubber
Hardwood wheels
Hardwood thrust button
Coloured tissue
Tiny tube of glue
Nose block
Celluloid for windshield

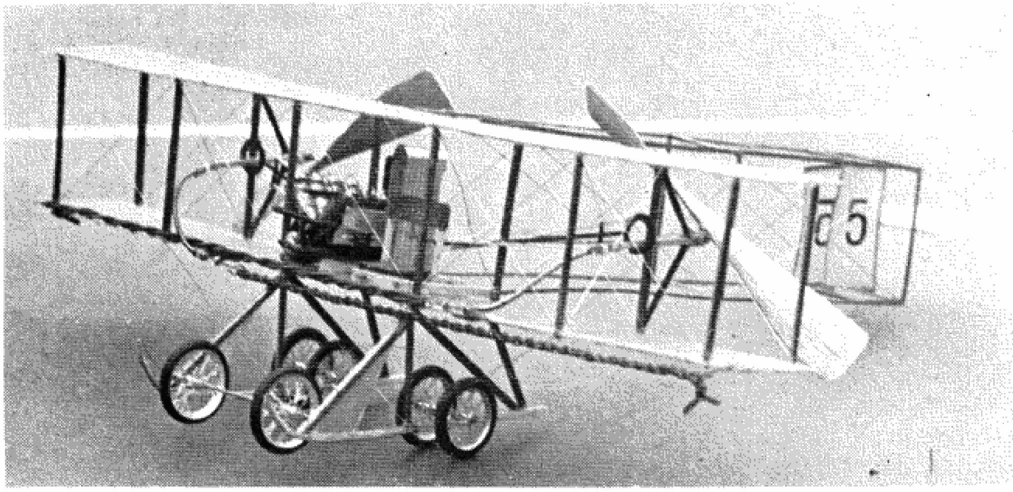
Today, ten cents will just about cover the cost of two strips of $\frac{1}{16}$ in. square stripwood!

When Dave Stott and Bob Thompson of the Bridgeport, Connecticut, Flying Aces Club were composing the rules for their new Peanut Scale event, back in 1967, they began by examining sets of plans from these pre-war kit models. At first, their rules specified a 12-in. span, with a plus and minus tolerance, to allow for inevitable variations in man-made products. Then, after the event had been tested, it was discovered that a number of plans were available in old magazines that were almost 13 in. span. Thus, the limit was raised to 13 in., with the firm provision that no additional stretching would be tolerated.

Originally, the rules called out a lower limit also, but this segment was eventually dropped, as few contestants cared to build anything smaller than necessary. Thus the upper limit was frozen, where it remains today, and has gained world-wide acceptance.

Typical Bill Hannan plan below; opposite, a Baby Wright racer with lateral flexidrive to props by Fulton Hungerford—it's a Peanut! Photo by Tybee Vidal.





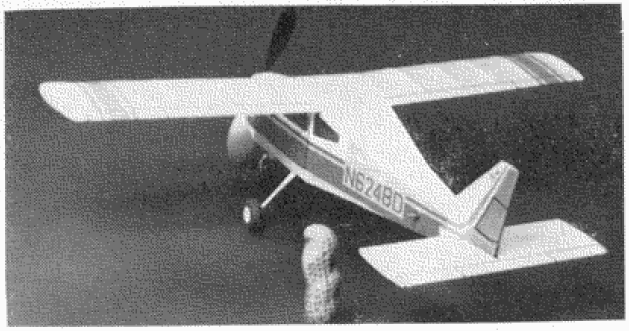
FLYING scale aircraft have been around for a long time, and, in fact, they predated the man-carrying machines in some cases. Yet, very small examples have seldom been taken seriously, and have long been overshadowed by their larger cousins. Perhaps theorists are partly responsible for this state of affairs, since they have repeatedly pointed out in the modelling press that the bigger the model, the more efficient it can be. By way of explanation, the slide-rule pushers invariably single out that great aerodynamicists' escape clause, the Reynolds Number. Like the infamous U.S. Air Force unidentified flying object investigation, which set out to "explain away" every unsolved sighting, the Reynolds Number pitchmen have blithely by-passed any practical research into the flying potential of miniature flying machines.

Thus, tiny flying models, of the scale variety, are in approximately the same predicament as the humble bumble bee. They really shouldn't perform so well. But they do, anyhow!

Prior to World War Two, many model aircraft manufacturers produced kits in the under 24-in. wing span range, and some of us gained our first introduction to the hobby from them. Typically, we were seldom able to achieve anything more than marginal flights from them, owing primarily to lack of experience. In my neighbourhood, for example, such "exotic" items as mechanical winders and rubber lube were simply unknown! And, as we grew older and wiser, our attentions were turned to larger models. Yet, the memories lingered on, and I suspect the nostalgia factor has more than a little to do with the present re-emergence of interest in the type.

In the United States, small scale flying model flying has developed along two rather distinct lines; over 13-in. wing span, and under 13-in. wing span. We will attempt to present some information about both types, and trace the history of the smaller category, which has become known as the "Peanut Scale class".

For many years, radio-controlled models have held the spotlight. These highly expensive and sophisticated aircraft were considered the ultimate in the expression of the modeller's art. And there can be no doubt that some fantastic achievements have taken place, particularly in the scale class. The competition became so fierce, that only a handful of super-craftsmen were able to come within striking distance of the winner's circle. Thus was born a new division, "stand-off scale", which was envisaged as a class where "Joe average" would



Bill Hannan's original BD-4 13 in. Peanut, plans reproduced opposite, a very simple design, easily made.

have a chance at recognition with his less-than-museum-quality model. And the tremendous response to this new class, both by model builders and kit manufacturers, indicates the scope of interest in this type of model.

Similarly, in the free flight scale arena, over-specialization was reducing competition to a relative handful of experts. Then, too, inroads in housing developments meant decreasing flying site availability, a factor that was taking its toll in all forms of outdoor model flying. And, a parallel hampering situation was the increasing number of public complaints regarding the noise created by engine-powered models.

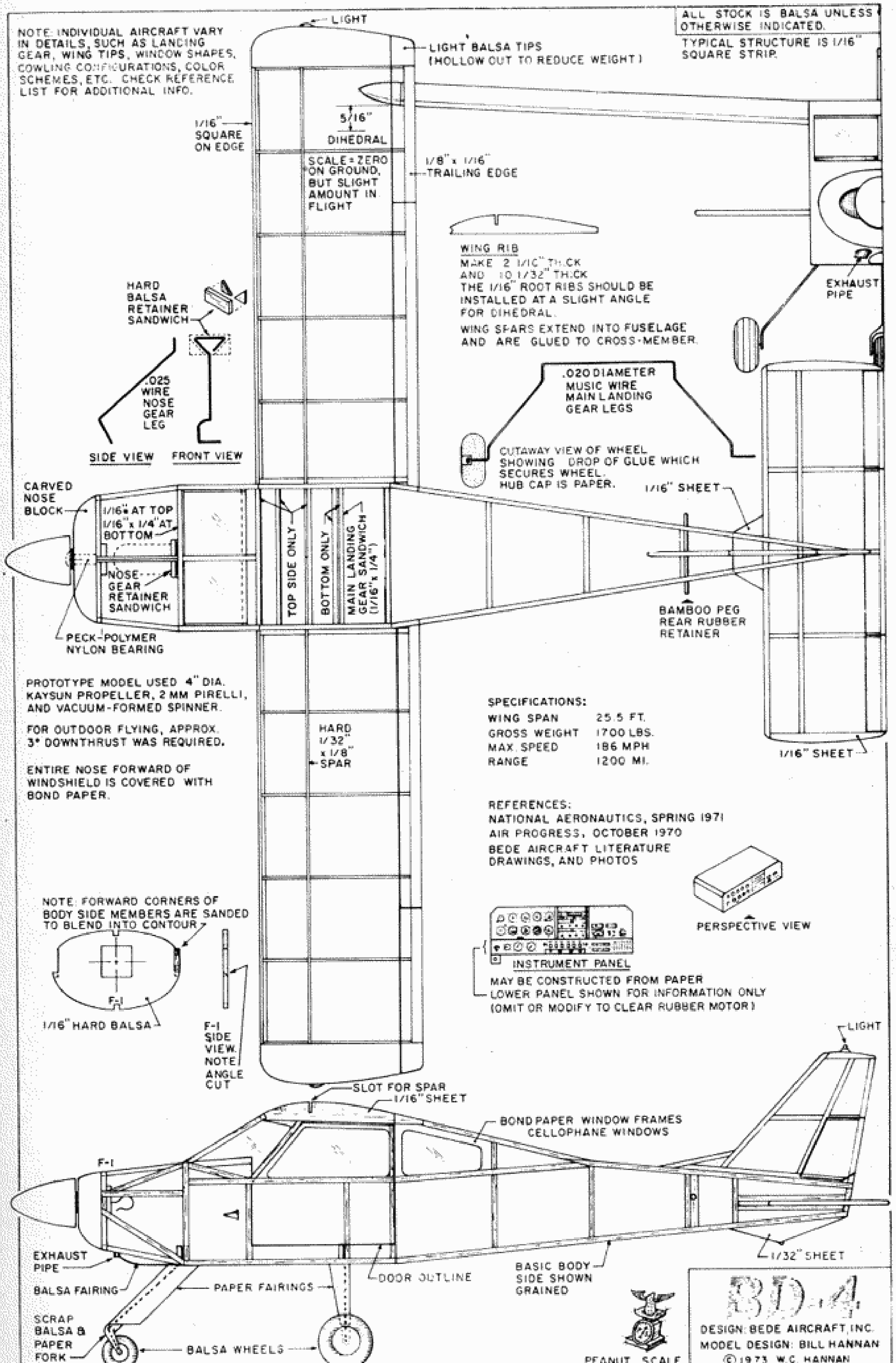
Soon, some modellers began to search for alternate ways of pursuing the enjoyment of scale model aircraft flying, by dipping into the past. Answer? The "old-fashioned" rubber-driven type! Here was the class that most "experts" had written off as an antiquated entertainment for inexperienced people. It remained for a small number of dedicated small-model enthusiasts to demonstrate the real charm and flying potential of miniatures. True, such models had continued to appear, over the years in the modelling press, and yet, the finished article was seldom in evidence at the local flying sites.

In the U.S., on the West Coast, a single club, the (then) North American Aviation Flightmasters (now, Rockwell International Flightmasters) clung steadfastly to the belief in rubber-driven models, by sponsoring events for them at least two or three times per year. While on the East Coast, another club, the Flying Aces, of Bridgeport, Connecticut, proclaimed their faith in the type, by sponsoring *only* contests for rubber-driven types. Their rules, which offered incentive for out-of-the-rut types, rather than such "safe" subjects as Piper Cubs, were so warmly received that soon they invented a separate set of rules, designed specifically to cater to even smaller rubber-driven models, the now famous Peanut Scale class (see Introduction).

It is interesting to note that the first formal contest was won by renowned builder, Henry Struck, who entered a 12-in. span Howard "Pete" racer. In the beginning, the event was envisaged as an outdoor affair, but it wasn't long before some clubs were also conducting such contests in hangars and gymnasiums.

Soon members of the Flightmasters were comparing notes with Dave Stott and Bob Thompson, innovators of Peanut Scale, and next these tiny models were spreading in popularity all the way across the United States, and recently the types have been accepted in such countries as England, Germany, Mexico, Canada, Australia, and Poland

Of course, in England, such enthusiasts as Doug McHard, Ken McDonough and Ray Malmstrom had long held the candle aloft for tiny flying scale models.



NOTE: INDIVIDUAL AIRCRAFT VARY IN DETAILS, SUCH AS LANDING GEAR, WING TIPS, WINDOW SHAPES, COWLING CONFIGURATIONS, COLOR SCHEMES, ETC. CHECK REFERENCE LIST FOR ADDITIONAL INFO.
LIGHT
LIGHT BALSA TIPS (HOLLOW OUT TO REDUCE WEIGHT)
ALL STOCK IS BALSA UNLESS OTHERWISE INDICATED.
TYPICAL STRUCTURE IS 1/16" SQUARE STRIP.
1/16" SQUARE ON EDGE
5/16" DIHEDRAL
SCALE = ZERO ON GROUND, BUT SLIGHT AMOUNT IN FLIGHT
1/8" x 1/16" TRAILING EDGE
WING RIB
MAKE 2 1/16" THICK AND 10 1/32" THICK
THE 1/16" ROOT RIBS SHOULD BE INSTALLED AT A SLIGHT ANGLE FOR DIHEDRAL.
WING SPARS EXTEND INTO FUSELAGE AND ARE GLUED TO CROSS-MEMBER.
EXHAUST PIPE
HARD BALSA RETAINER SANDWICH
.025 WIRE NOSE GEAR LEG
SIDE VIEW
FRONT VIEW
.020 DIAMETER MUSIC WIRE MAIN LANDING GEAR LEGS
CUTAWAY VIEW OF WHEEL SHOWING DROP OF GLUE WHICH SECURES WHEEL. HUB CAP IS PAPER.
1/16" SHEET
CARVED NOSE BLOCK
1/16" AT TOP 1/16" x 1/4" AT BOTTOM
NOSE GEAR RETAINER SANDWICH
TOP SIDE ONLY
BOTTOM ONLY
MAIN LANDING GEAR SANDWICH (1/16" x 1/4")
BAMBOO PEG REAR RUBBER RETAINER
PECK-POLYMER NYLON BEARING
PROTOTYPE MODEL USED 4" DIA. KAYSUN PROPELLER, 2 MM PIRELLI, AND VACUUM-FORMED SPINNER.
FOR OUTDOOR FLYING, APPROX. 3° DOWNTHRUST WAS REQUIRED.
ENTIRE NOSE FORWARD OF WINDSHIELD IS COVERED WITH BOND PAPER.
HARD 1/32" x 1/8" SPAR
SPECIFICATIONS:
WING SPAN 25.5 FT.
GROSS WEIGHT 1700 LBS.
MAX. SPEED 186 MPH
RANGE 1200 MI.
1/16" SHEET
REFERENCES:
NATIONAL AERONAUTICS, SPRING 1971
AIR PROGRESS, OCTOBER 1970
BEDE AIRCRAFT LITERATURE
DRAWINGS, AND PHOTOS
NOTE: FORWARD CORNERS OF BODY SIDE MEMBERS ARE SANDED TO BLEND INTO CONTOUR
F-1
1/16" HARD BALSA
F-1 SIDE VIEW. NOTE ANGLE CUT
PERSPECTIVE VIEW
INSTRUMENT PANEL
MAY BE CONSTRUCTED FROM PAPER
LOWER PANEL SHOWN FOR INFORMATION ONLY (OMIT OR MODIFY TO CLEAR RUBBER MOTOR)
LIGHT
SLOT FOR SPAR
1/16" SHEET
BOND PAPER WINDOW FRAMES CELLOPHANE WINDOWS
F-1
EXHAUST PIPE
BALSA FAIRING
PAPER FAIRINGS
DOOR OUTLINE
BASIC BODY SIDE SHOWN GRAINED
1/32" SHEET
SCRAP BALSA & PAPER FORK
BALSA WHEELS
PEANUT SCALE
BD-4
DESIGN: BEDE AIRCRAFT, INC.
MODEL DESIGN: BILL HANNAN
© 1973 W.C. HANNAN

Why the appeal? Consider the following:

1. They are quite inexpensive to construct. The total cost of a Peanut, complete with rubber motor, will seldom approach the cost of the fuel for a day's R/C flying!
2. They are easy to transport. There is no need for removable or "knock-off" wing panels, or exotic carrying cases. A small pasteboard box makes a perfect "hangar".
3. They are clean. No messy fuel, exhaust, or hot-fuel rotting problems.
4. They are quiet. An especially important factor in today's noise-pollution-oriented society.
5. They are durable. When this type of model crashes (and of course they do!), damage is usually less severe than it would be in a larger, heavier model. Simile: An ant falling off a cliff will most likely survive, but not an elephant! Thus, the useful life of a small model is often an entire flying season, or longer. Some, here in Southern California, have been flying in active competition for six years.
6. Small models are adaptable. They may be flown indoors or outside. Most fellows build general-purpose models, but more dedicated pilots build special light-weight examples for indoor use, and rugged ones for outdoors.

Peanuts have proven surprisingly adaptable to events which might seem outside their sphere of effectiveness. For example, some have fared very well against larger rubber-driven scale models in major contests. Others have placed well in rubber-driven speed events, again competing with much larger examples.

Ground Support Equipment

It is interesting to contrast the contents of a typical Peanut Scaler's field box with that of an R/C flier's: On the one hand, the "with it" electronically guided model pilot may quite likely have, in addition to the aircraft itself, a transmitter, starting batteries, battery leads, electric engine starter and battery for same, fuel, fuel pump, electronic tachometer, tools, ear-protection devices, spare props, glow plugs, gunk remover, etc., etc., etc.

By contrast the rubber-driven model enthusiast can quite adequately get by with only a winder, rubber lube, spare motor(s) and perhaps a few straight pins and glue, in case minor repairs are needed. Thus, the total investment in the entire model *and* ground support equipment will seldom exceed the cost of the *muffler* on the R/C model!

All told, a maximum of fun and satisfaction for a minimum investment of time and money.

Examples of rules are given elsewhere in this article. However, individual clubs often modify the rules to suit their particular desires. Typically, the

13 in. Peanut Fokker F-II in K.L. 1 livery.

"regular" rubber-driven scale models are flown under rather stringent regulations, with a great deal of attention to static scale judging, whereas the Peanut Scales are regarded more nearly in the "stand-off" scale vein.

"Nit-picking" is discouraged, but the spirit of the event encourages improvement of the art. Although the upper span limit is 13 in., many of the present records are held by models of less than the maximum allowable span.

Specifics

From an appearance standpoint, Peanuts run the gamut from extremely stark "ghost" ships (thinly disguised microfilm models), to models that would nearly qualify for inclusion in museum collections.

As in all other types of scale model competitions, the builder is expected to provide the judges with proof-of-scale material. Thus research is an important facet of small rubber-driven model work. Curiously, some consider this a bother and will generally run around frantically looking for a 3-view drawing to "match" his model, *after* he has constructed it! A more logical approach is to select one's scale information in *advance* of building the model. Very seldom are plans dead accurate, and 3-view drawings should be regarded with suspicion until proven valid. Photos are the safest form of information, assuming one allows for camera angle distortions. Although Peanut rules do not require photos of the real aircraft to be shown, inclusion of a few along with a 3-view drawing can certainly provide a more convincing presentation for the judges.

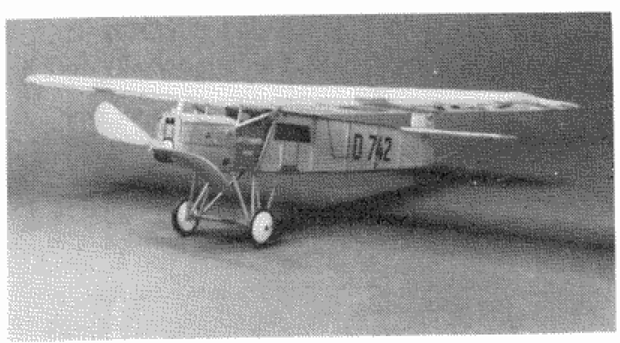
Since Peanut Scale is not intended to be as "serious" as regular scale, the author feels that it makes a fine outlet for those designs one frequently encounters, about which only a limited amount of information can be found. Some of these obscure types make delightful model subjects, even if a few details must be "guessed in".

Sources of Plans and Kits

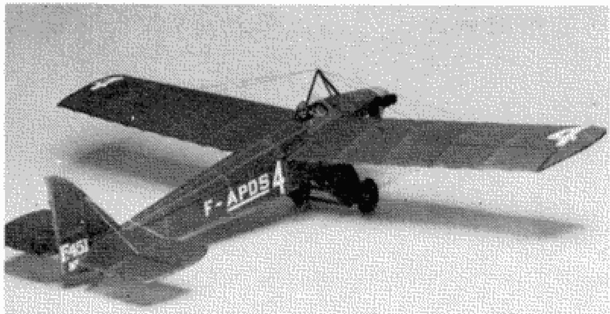
Check the advertising in the various model magazines for suppliers. Some of the "Old-Timer" plans offered by sale by mail are also small enough to qualify for Peanuts. The MAP range of scale drawings is exceptionally broad, and many of the subjects would make delightful Peanuts.

Construction

Peanuts require very little material, and can be constructed in small work spaces. A local airline pilot, C. G. Scott, carries his Peanut workshop in an attaché case, to be worked on during airport layovers. Roald Tweet, an English professor, keeps a Peanut in his desk drawer, to be "operated upon" during free class periods.



Fokker F-II in Lufthansa colours another of the author's models.



Farman Moustique—simple mid wing model which was sent to Britain for proxy entry in the British Indoor Nats by Bill Hannan.

Others build two or more Peanuts simultaneously. Hal Swanson, of Modernistic Models, has been seen constructing as many as five at once, switching as required, to allow time for glue to dry. Great therapy for those with a short attention span!

Some Peanuts are almost entirely sheet balsa, while the majority are of traditional "stick and tissue" form. A few use combinations of techniques, such as sheet wood or planked fuselage, used in conjunction with built-up tissue-covered wings and tailplanes.

Materials

Balsa, logically enough, forms the basis for the vast majority of Peanuts, although some builders are delving into the use of expanded foam plastic. Basswood has its adherents, and is easier to laminate than balsa, for such items as curved wing tips. And, in some instances, a $\frac{1}{32}$ square strip of basswood can take the place of a $\frac{1}{16}$-in. square piece of balsa, with equal or less weight.

Adhesives

Builders have different preferences when it comes to glues. Some prefer the traditional cellulose type of cement; others use white glue (P.V.C.) or aliphatic resin, while still others employ five-minute epoxy.

Covering Material

Japanese tissue is the universal favourite, since it combines light weight, good strength and pleasing colours. Since it is now in short supply, alternatives have been pressed into service. For strictly indoor models, condenser paper is sometimes used. Although fragile, it is non-porous and very light in weight. A few of the extremely thin mylar films have also been used. Note, however, that some rules handicap these types of covering, which in general do not present a particularly realistic appearance.

Most of the all-sheet models are covered with coloured tissue, while others are painted or dyed.

Propellers

Propeller theory controversy is as unresolved here as in any other form of aircraft. However, in the interests of simplicity, many Peanuts use readily available plastic props. These are surprisingly efficient, and usually crash resistant. Characteristics of different brands vary, and experiments are well worth the while. Plastic props have the added advantage of concentrating their weight to the extreme front of the model, a useful attribute on short nose-moment designs.

On the other hand, there is a lot to be said in favour of the "old-fashioned" wood propeller. Some prefer the machine-cut blank type, which requires only a small amount of finishing, while others prefer to carve their own from blocks. Then, too, the sheet-balsa blade and built-up hub approach has its merits.

Detailing

As with any type of scale modelling, it is the little things that set a winner apart from a mediocre example. One must constantly be aware of the performance penalties of weight increases, however, when adding details to Peanuts. Happily, much can be achieved with very light materials, such as coloured tissue and thin paint. Panel lines and control surface outlines can be simulated with thin tissue strips or simply inked on. Those who think the amount or quality of details must be limited by the model's small size, are encouraged to visit an I.P.M.S. display, to see what can be achieved in the way of finesse and intricacies in *really* small models!

Modifications From Scale

Although the intent of the rules is to encourage realism, the typical Peanut will be found to have certain modifications performed, in the interests of improving performance. Landing gears are often lengthened for greater prop clearance. In areas where models are flown hand-launched only, the props are sometimes simply extended, and the landing gear left in scale position. In the case of a modelled real aircraft with retractable landing gear, the wheels are simply represented as being in the "up" position.

Enlarging the horizontal tailplane often makes flight trimming easier, although purists have proven that minimal scale areas can be persuaded to work, with forward C. G. locations, proper airfoils, and careful adjustments.

The dihedral is frequently increased, especially in the case of low-wing aircraft. Typically, the judges of Peanut Scale appreciate the advantages of such changes, and are inclined to be lenient in their evaluations. Yet, a surprising number of Peanuts have been successfully flown with scale 0° dihedral. Most of these have been high-wing or biplane types, however. A generous application of wash-out to both wing panels is less visually obvious than a dihedral increase, and can greatly assist the cause. On indoor Peanuts, the no-dihedral approach has proven relatively easy, but flown outside, the models seem liable to upsetting by wind gusts.

Flying

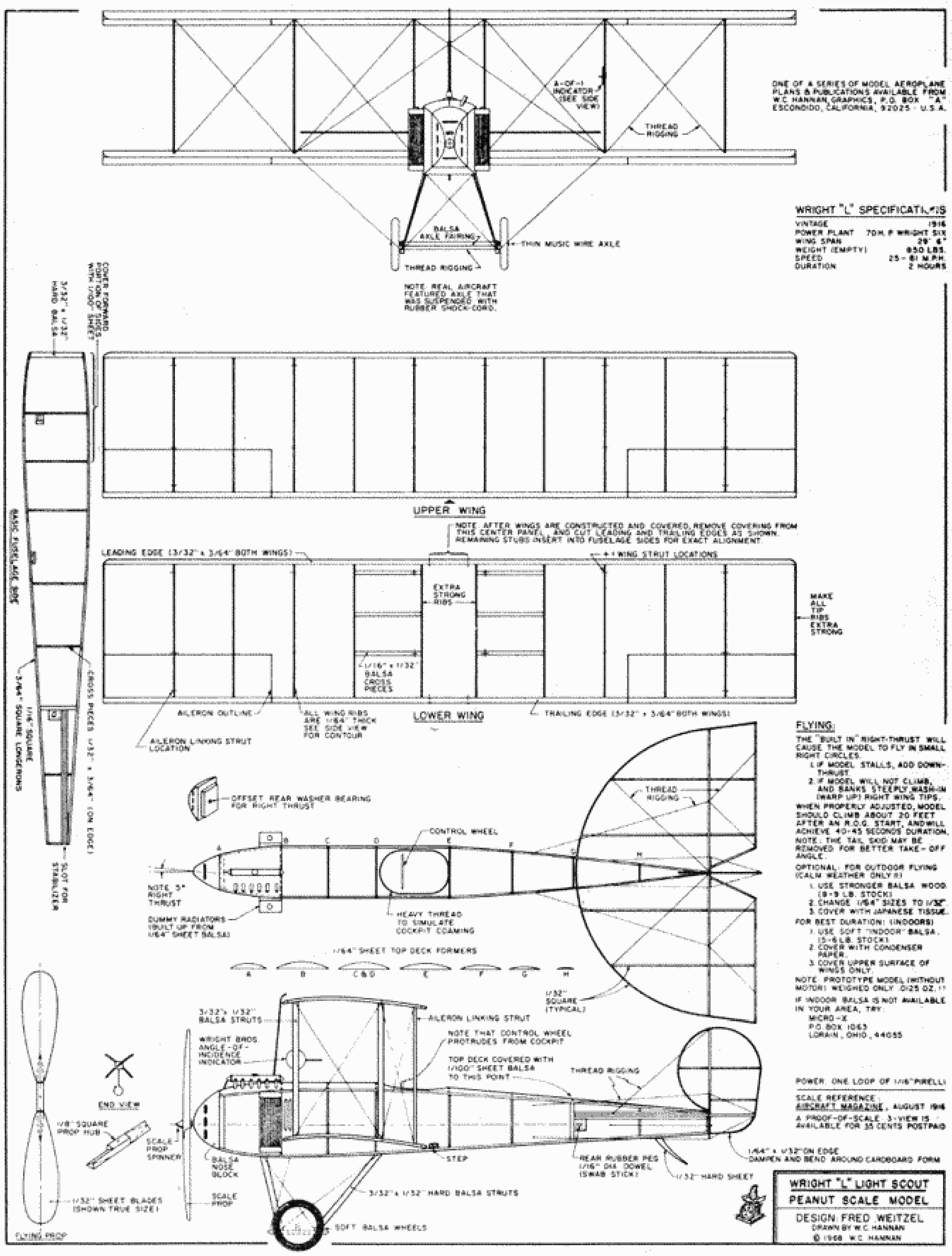
While the construction and finishing of a Peanut may be considered an art, flying it combines art, science and at least a modicum of luck! The usual admonishments regarding freedom from unintentional warps and correct surface alignment apply here, just as in any other form of model flying.

Indoor fliers agree that the ideal is the longest possible rubber motor run, coupled with the slowest possible flight. The optimum prop/power combination results in the model landing with a few turns remaining in the motor. That is to say, no glide is involved in the flight.

Outdoors, there are two distinct schools of thought. One group favours an approach similar to the indoor system, wherein the model cruises around on fairly limited power, with a long duration motor run.

The opposite tack involves blasting the model to altitude with high power, with the glide constituting a significant portion of the total flight. Some of these "interceptor" type models will climb almost vertically, and can quickly reach amazing heights. The typical Peanut does not glide very well, however, even with a free-wheeling prop—probably because the prop represents such a major proportion of the model's total drag.

Either type of model performance can be considerably affected by the prevailing weather. Thermals can benefit either type, but high winds can literally put the ultralight models out of action.



Performance

This is the area of the biggest "breakthrough" of modern Peanuts, as compared to the old "10-cent kit" models. With many *very* experienced builders flying Peanut Scale models, improvements have been evolved and techniques refined to the point of a fine art, both in construction and flying.

Peanuts have demonstrated conclusively that a model need not be large to perform spectacularly. Indoor versions approach the 60 sec. mark commonly, and a few of the "ghost ships" have achieved durations in the order of five minutes

Outdoors, the sky is literally the limit, and a few Peanuts have disappeared out of sight under officially sanctioned conditions. The author personally witnessed a nine-minute plus flight by one of Clarence Mather's Peanut Scale models. Yet, this same model had also performed within the confines of a small gymnasium, demonstrating the adaptability of these tiny machines.

Weight

Peanuts range from a low of about ⅛ oz. for a strictly indoor "ghost" ship, to about 1 oz. for some outdoor "flying bricks". Most run somewhere between these two extremes, and my guess is that an average might be about ½ oz.

Power

Pirelli rubber, scarce as it is, is still the preferred motive power. Sizes as small as 1 mm are used in the ultralight indoor types, while sizes as large as 4 mm are used in a few outdoor high-climbing "hot-rods". Again, the average might be somewhere in the 2 mm area.

Variety

One of the most popular features of the Peanut Scale class, is the variety of designs it attracts. Seemingly impractical types involve very little risk in Peanut form, and the low cost involved encourages builders to experiment with "oddballs" that they might hesitate to undertake in larger form. Thus, antiques, canards, multiplanes, pushers and such abound in Peanut contests.

Selecting a Subject

Peanuts are unique in that the upper wingspan limit has such a strong effect on the choice of scale subject. Thus, for example, some racing aircraft translated to Peanut form emerge with enormously long fuselages, whereas high-aspect ratio designs may yield only tiny fuselages and very minimal wing areas.

Ideally, one should look for a fairly low-aspect ratio design, with long nose-moment, large horizontal tailplane, adequate dihedral and (hopefully) a charming appearance to woo the judges and spectators. Admittedly a tall order but the looking is half the fun!

Future

Great vistas remain unexplored. Areas deserving exploration include: Variable pitch propellers; multi-engine designs (hint: take a look at some of the American twin prop "coin" fighters); contra-rotating prop designs; pusher-puller types.

Along the gamesmanship lines, we could all take a leaf from the I.P.M.S. members, and think in terms of presenting the judges with a complete Peanut Scale diorama!

Postal Meets

Peanuts open up new horizons for truly international postal meets. Usual postal meets involve the flying of models made to specified rules in several locations, and mailing the duration times in to a central point for evaluation and scoring. But with Peanuts, it would be quite practicable to mail *the models* themselves to a central point, anywhere on earth, for *direct* competition! For the first time in the entire history of aeromodelling, an event would be available to enable even the most financially limited enthusiast to participate! Since the models are so small and light, they can be quite inexpensively mailed for proxy-flying.

Who will start the ball game rolling? After all, we can all play for "peanuts", and we won't have to "shell out" much!

JUDGING GUIDE

(Free flight indoor rubber scale)

UNIT	BASIC POINTS		ADDED POINTS				POINTS SCALE	POINTS MAX
I: WING	Double Surfaced +15	Single Surfaced +3	Scale Rib. Spar. Area & Aileron +5 max	Scale Dihedral +5 max	Slight Dihedral Deviation +1 to +2	Gross Dihedral Deviation 0 to +1		25
II. STABILIZER	Double Surfaced +6	Single Surfaced +1	Scale Rib. and Spar +2 max	Scale Area +2 max	Slight Area Deviation +1	Gross Area Deviation +0		10
III. FIN AND RUDDER	Double Surfaced +3	Single Surfaced +1	Scale Rib and Spar +1 max	Scale Area +1 max	Slight Area Deviation +1/2 max	Gross Area Deviation +0		5
IV. FUSELAGE			Scale Contour and Constr. +10 to +8	Slight Scale Deviation +7 to +5	Medium Scale Deviation +4 to +2	Gross Scale Deviation +1 to +0		10
V. LANDING GEAR, STRUTS AND RIGGING			Full Scale +10 to +8	Slight Scale Deviation +7 to +5	Medium Scale Deviation +4 to +2	Gross Scale Deviation +1 to +0		10
VI. ENGINE COWL, AND ACCESSORIES			Excellent +20 to +16	Good +15 to +11	Fair +10 to +5	Poor +4 to +0		20
VII. FINISH, WORKMANSHIP, MARKING, AND COLOURING			Excellent +20 to +16	Good +15 to +11	Fair +10 to +5	Poor +4 to +0		20
					TOTAL SCALE POINTS			100
					FLIGHT POINTS			
					TOTAL POINTS			
					CONTEST PLACE			

FREE FLIGHT PEANUT SCALE (PROVISIONAL)

1. Applicability. All pertinent A.M.A. regulations (see sections titled Sanctioned Competitions, Records, Selection of National Champions, and General) shall be applicable except as specified below.
2. General. Open to any scale model of no more than 13 in. wingspan.
3. Scoring. Total of three flights, hand-launched, to be used in addition to Construction and Workmanship points to determine winner. Flyoff to break any tie.
4. Official Flight. Unlimited attempts to gain three official flights. Any flight of 5 secs. or more is automatically official.
5. Construction Scoring, General.
    A. Use of condenser paper instead of Jap tissue. Minus 10 pts.
    B. No microfilm allowed.
6. Construction Scoring, Flight Surfaces.
    A. All or partial sheets. Minus 5 pts.
    B. Built-up, tissue covered (Jap tissue only) on top or bottom only Minus 5 pts.
    C. If proof can be shown that the real ship was covered on one side only and the model is also. Zero pts.
    D. Built-up with top and bottom covered. Plus 3 pts.
7. Workmanship.
    A. Colour—Reasonable effort to use tissue or (and) dope to simulate realistic coloring for type modelled. Plus 3 pts.
    B. Marking—Civil registration and striping or military insignia, serial nos. and squadron markings. Plus 3 pts.
    C. Details—Struts, cowls, cylinders, pitot, rigging, armament, windshields, steps and control surface outlines plus any unmentioned outstanding details for the type moulded shall be scored thus:
        1. Stark. Minus 3 pts.
        2. Lax. Zero pts.
        3. Good. Plus 3 pts.
        4. Great! Plus 6 pts.
    D. Planes that had retractable landing gear may be built with the gear represented in the up position.

FREE FLIGHT INDOOR RUBBER FLYING SCALE

1. Applicability. All pertinent A.M.A. regulations (see sections titled Sanctioned Competitions, Records, Selection of National Champions, and General) shall be applicable, except as specified below.
2. General. Models must be of any heavier-than-air, man-carrying aircraft. (However, 3-view drawings must be presented to allow judging for fidelity to scale. Unified Scale Judging Rules 4a through 4d define criteria for acceptable drawings.) Additional information presenting detail on aircraft features modelled, such as photos, sketches of construction, detail colouring and marking chart is encouraged.

2.1. Maximum wingspan is limited to 30 in. No limits are placed on propeller size or shape. A scale propeller can be substituted for judging, but no points will be awarded for it.

2.2 Two categories will be recognized: monoplane and multiplane. Contest Director must indicate which categories will be flown, or whether they will be combined.

3. Scale Judging Criteria. Scale judging will be the basis of 100 scale points to be awarded as per the judging Guide (opposite page).

3.1. If no drawings are presented, no points for fidelity to scale (items I and VI) will be awarded. However, workmanship points earned (item VII) will be awarded.

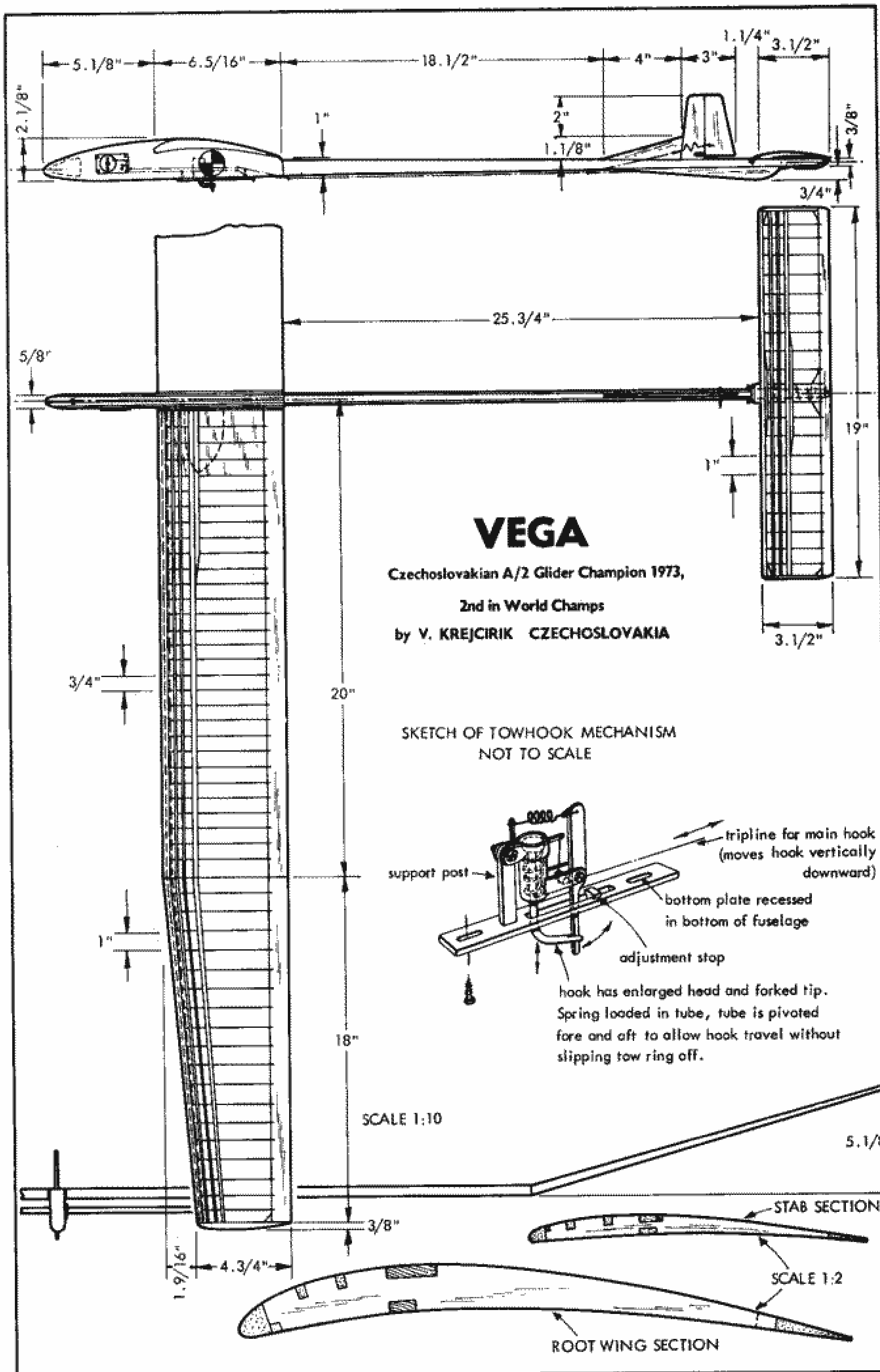
3.2. The Judging Guide is to be considered as an aid to uniform judging practice and is not intended to replace judgment on the part of the scale judge as to exact scores.

4. Flight Judging. Flying will be judged solely on duration following unassisted ROG.

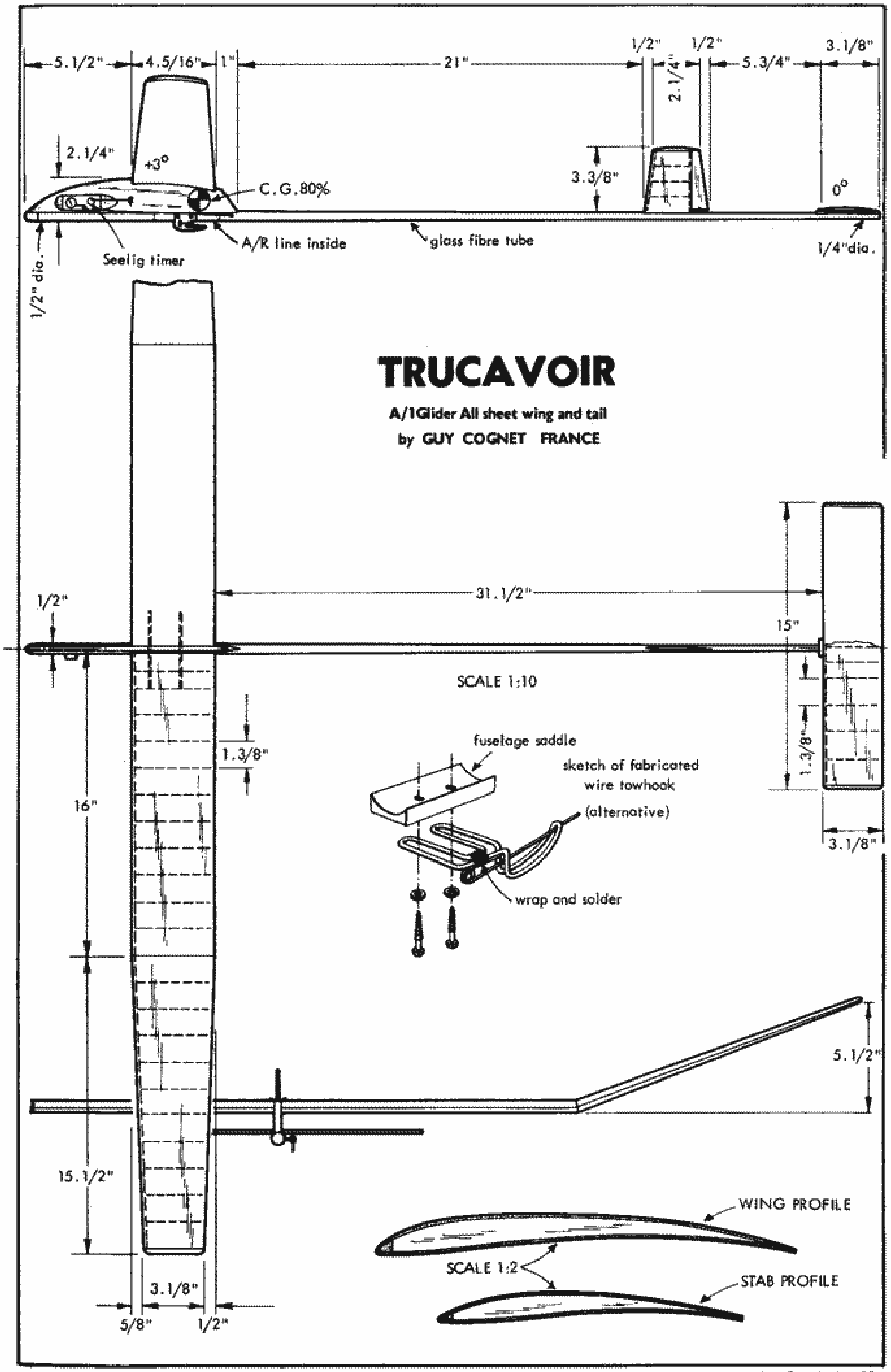
4.1. Model is allowed unlimited attempts to accomplish four (4) official flights. Time starts with release, and flight becomes official when model is airborne for five (5) secs.

4.2. Flight is terminated when model returns to floor or if model hangs up on any obstruction. If model bounces off obstruction above the floor and continues its flight, timing will continue. A bounce on take-off will not be considered as ending the flight unless model fails to achieve continuous flight.

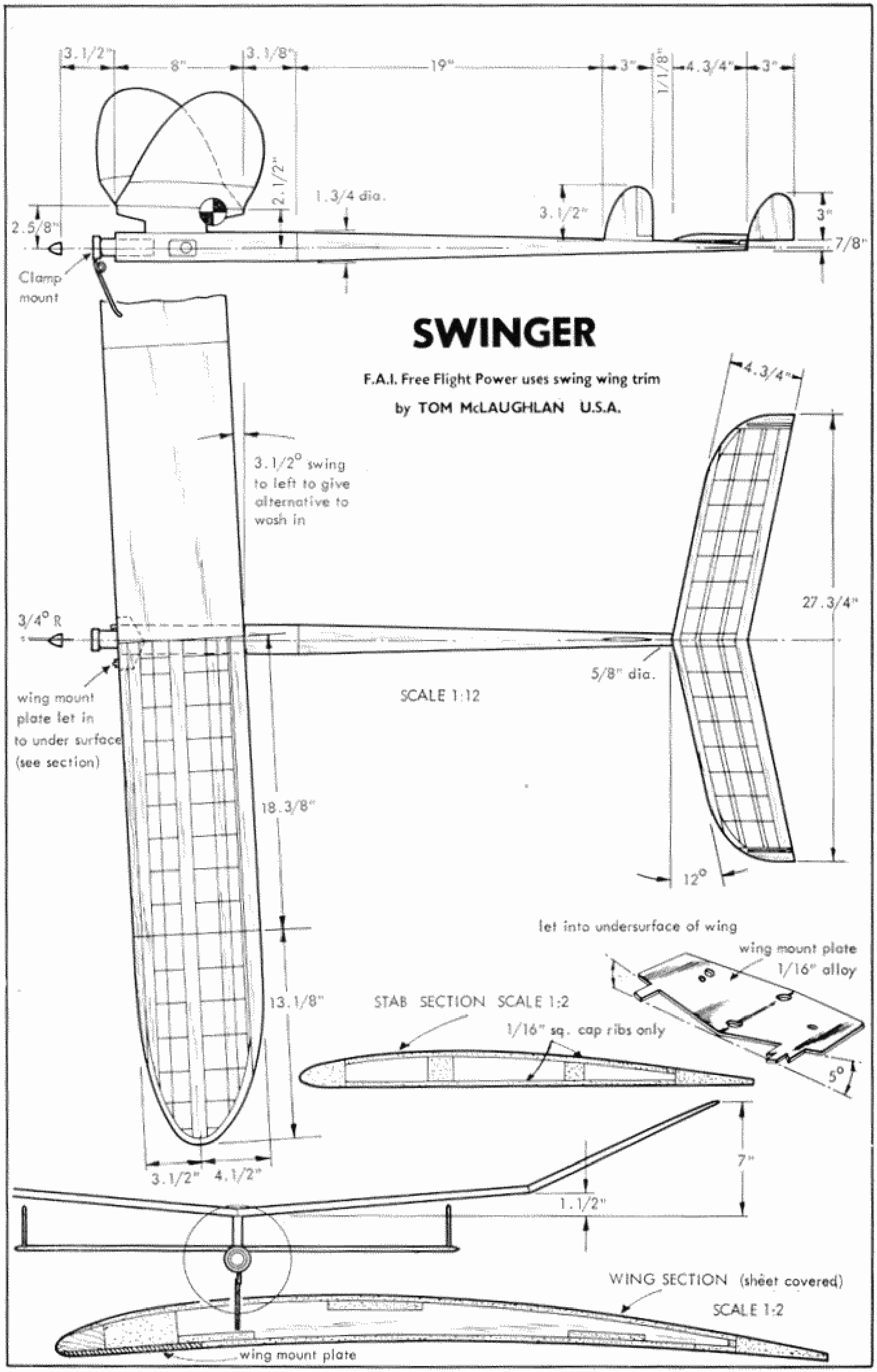
4.3. Flying points will be awarded for the longest official flight at one (1) point per sec., but limited to the maximum of the scale points awarded.



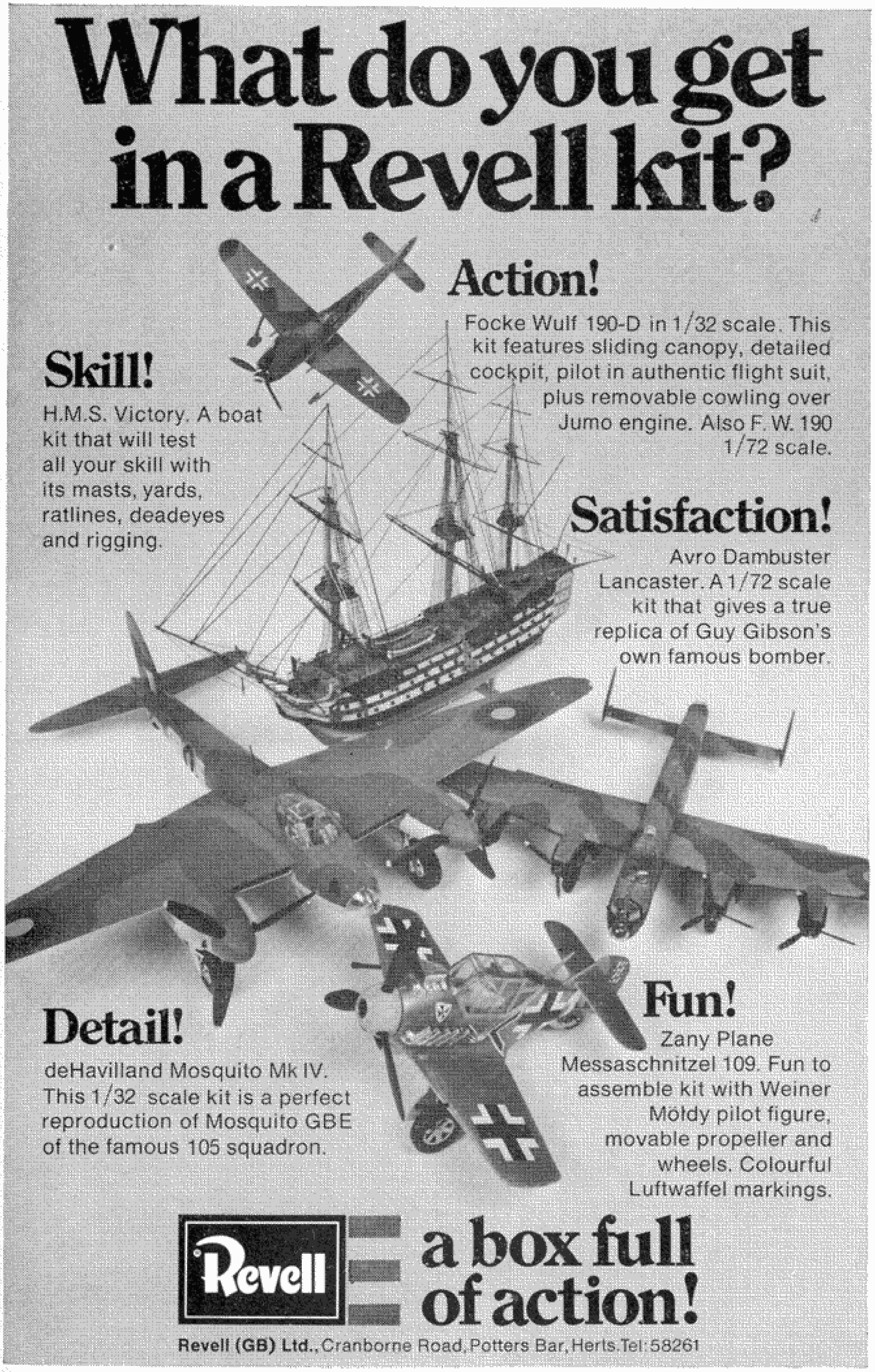
MODELARZ POLAND



MODELE REDUIT D'AVION FRANCE



FREEFLIGHT DOWNUNDER AUSTRALIA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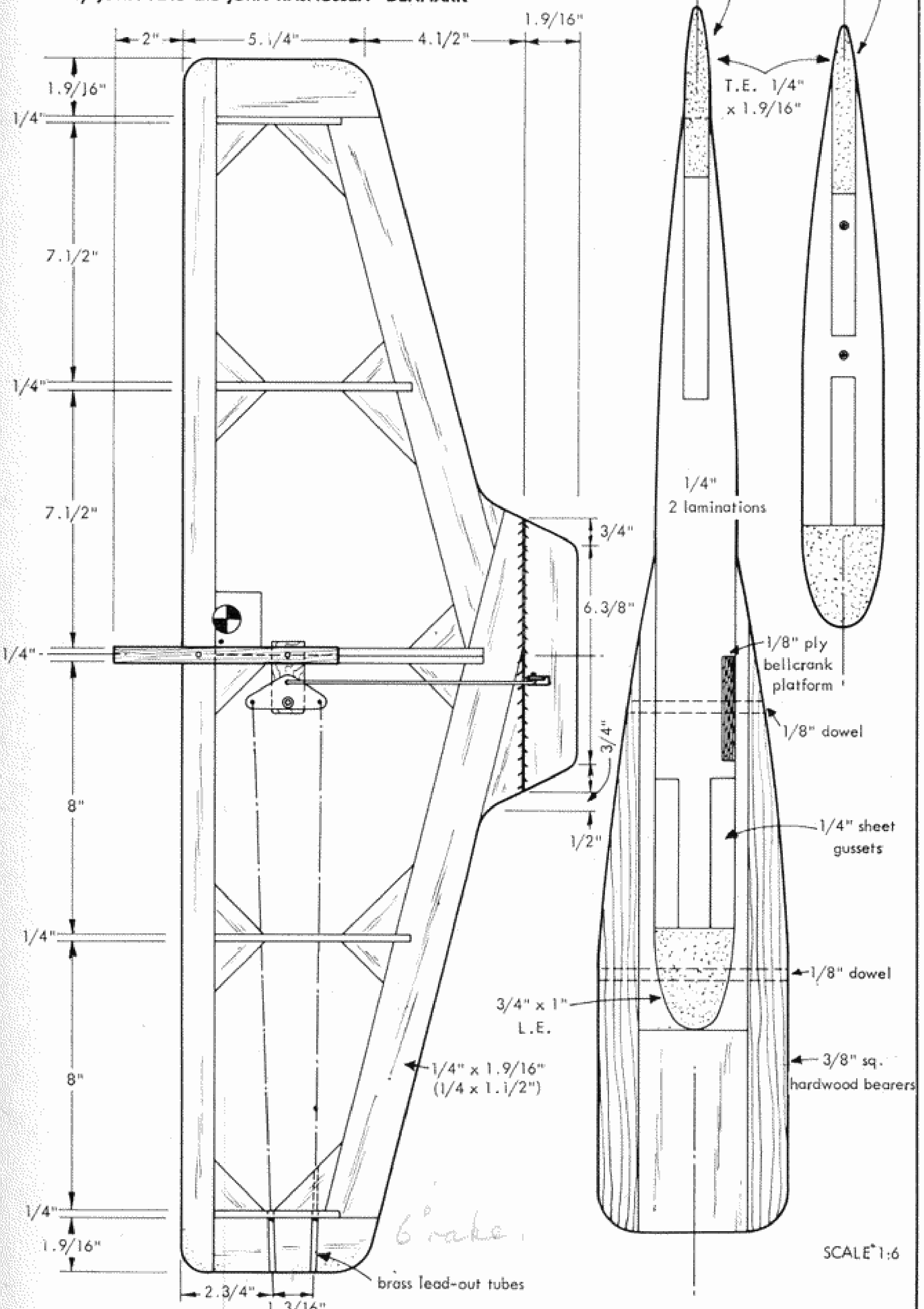
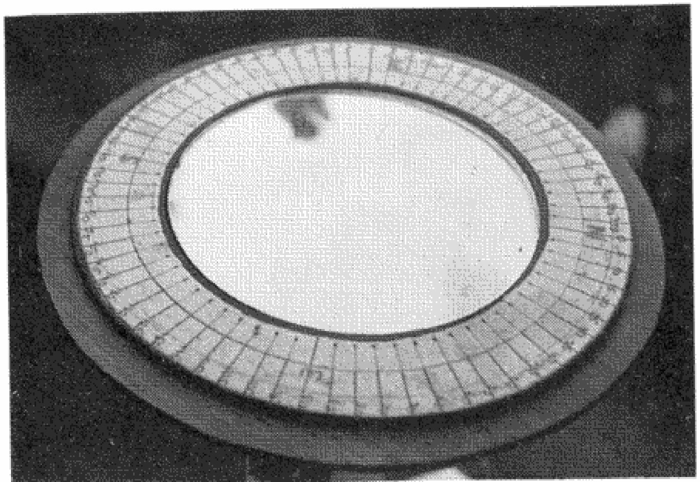
DANISH CHALLENGE

F.A.I. Combat—at British 1974 Nats

by JOHN MAU and JORN RASMUSSEN DENMARK

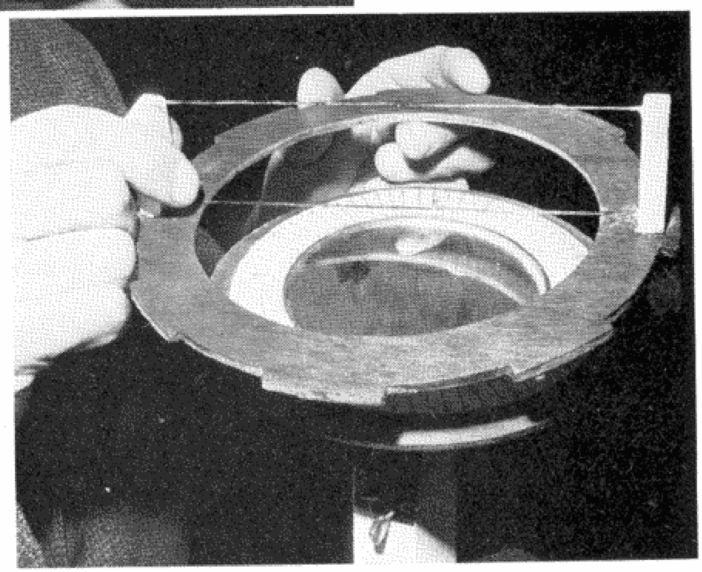
SECTIONS SCALE 1:2





Mirror set in centre of calibrated ring with compass points clearly marked, on a ply base, fretsawn to shape.

Slipping the sighting ring into position over the outside of the calibrated compass ring. The serrated edges are for grip, not entirely essential.



Author and his original unit, used for sighting aircraft headings, or locating the drift line of wayward models!

DRIFT INDICATOR

by P. A. Scorey

ORIGINALLY intended as a simple instrument with which to obtain a more precise direction of the upper winds by observing the clouds, the principle of the drift indicator as fixed to the floor of the cockpit of the *Vickers Vimy* used by Alcock and Brown on their trans-atlantic crossing in 1919 is reversed.

The instrument, which can be tilted at any angle either laterally or vertically is first aligned on true North with the aid of an ordinary compass by sighting through the two holes in the uprights, and then clamped to the collapsible stand.

When an object on which a bearing is desired (be it a cloud, airliner or model aeroplane), flying at a reasonable height appears to "fly" parallel down the reflection of the wires stretched across the mirror, the movable ring which is turned in the process against true North automatically gives the bearing of the target since the wires at the same time move over the static bearing ring.

The measurements on the drawing are by no means critical and in fact the mirror available dictates the size of the entire instrument. A larger mirror increases the area of "search".

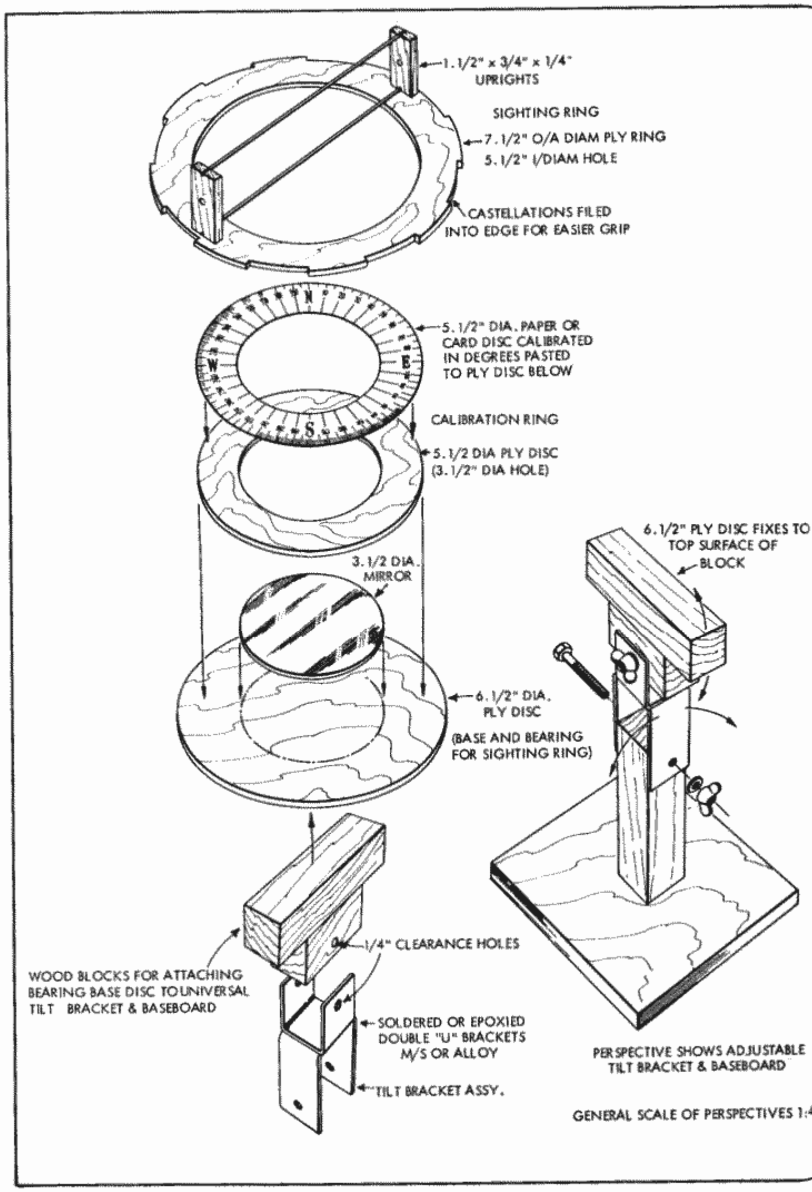
Construction

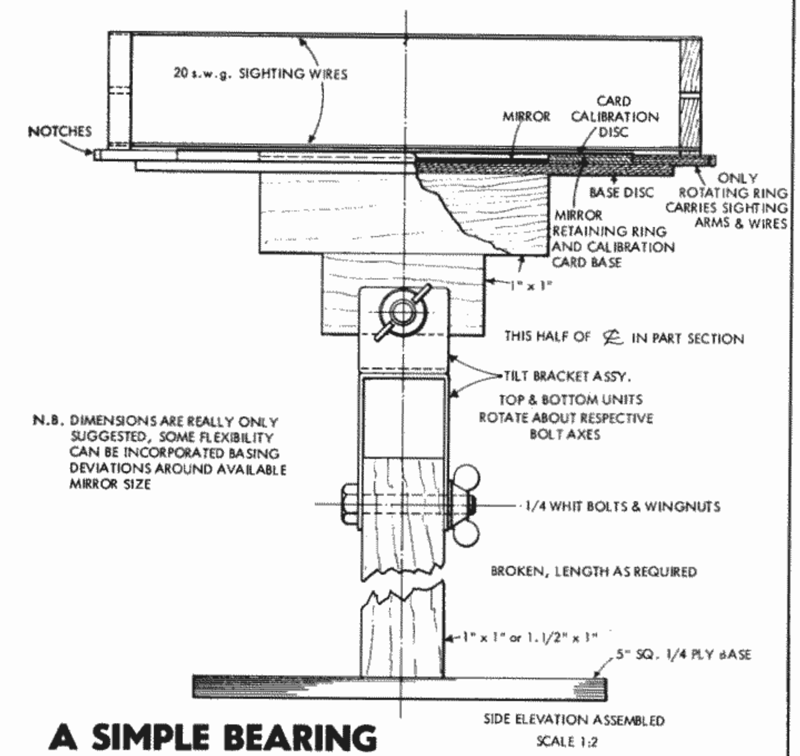
First obtain an ordinary round mirror. The one used was a spare car wing mirror of $3\frac{1}{2}$ in. diameter. Cut a circular piece of $\frac{1}{8}$-in. ply $6\frac{1}{2}$ in. diameter and place the mirror upon it. Frame the mirror with a circle of ply making it larger by 1 in. all round but before gluing it to the first timber draw out on a piece of paper a similar 1 in. ring dividing this first into quarters thus giving the position of N. E. S. & W. and with the aid of a protractor divide the entire circle into degrees. Paste this when completed to the ring of ply. Now glue into position thus framing the mirror with a static bearing ring. A larger ring of ply is now cut, notched on the circumference if desired and placed over the static ring leaving it free to revolve and resting on the first timber. Two small uprights are fixed onto the movable ring opposite each other and after they have each been drilled with a small hole for aligning purposes only, a piece of 20 s.w.g. wire is stretched across and fixed under the bottom of the upright whilst a second wire is placed on the top of the uprights. These wires which must be accurately set form a parallel reflection in the mirror.

The instrument is mounted on a stand 5-in. square and on the top of the $1\frac{1}{2} \times 1$-in. upright a double bracket is formed, ideally from two pieces of thin metal channel (though these can be made up in wood) drilled and allowed to swivel on the two bolts fixed in opposing directions thus making lateral and vertical movement possible. The top bolt is of course drilled through the block as detailed, the block having first been glued into position underneath the first circular piece of ply.

The instrument which is now complete can be set up on the field by making a suitable small collapsible table from four pieces of 2×1-in. timber inclined towards each other drilled at the same angle to receive $\frac{5}{8}$-in. detachable dowell legs on each side and a platform fixed on the top.

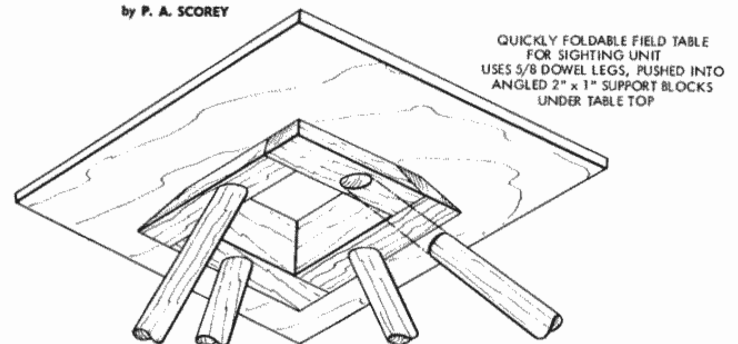
The skill of "capturing" a target and reading its bearing is soon acquired and can provide quite an amount of excitement though it must be appreciated, the higher the object the slower it appears to move across the mirror. It can of course also be used to fix a bearing on a tree etc. over which that wayward model was last seen flying. One last word—be careful of the reflection of the sun.



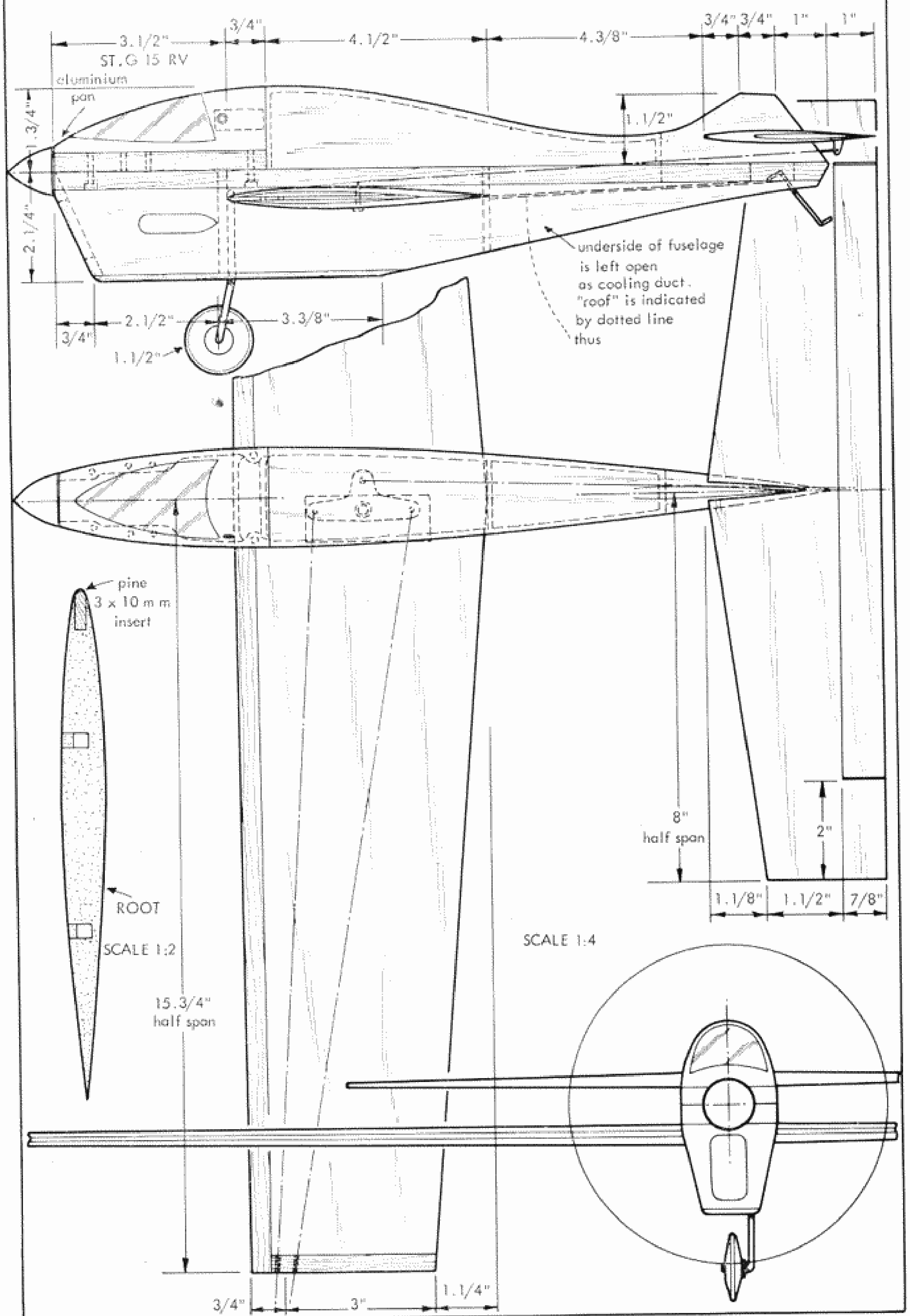


A SIMPLE BEARING INDICATOR

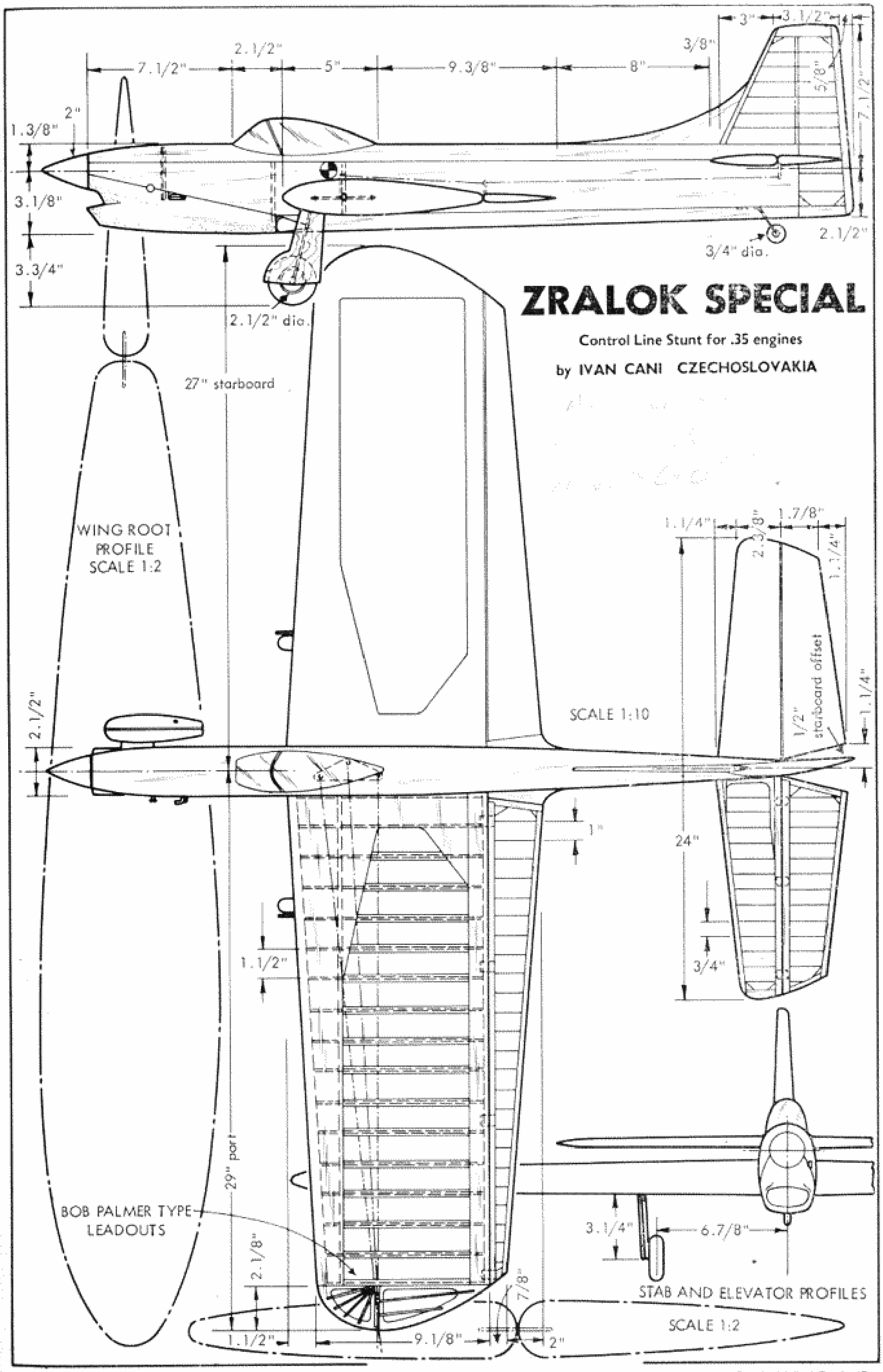
by P. A. SCOREY



DELFIN III F.A.I. Team Racer for 2.5 cc engines by G. PULIDO SPAIN



EL AEROMODELO SPAIN



MODELARZ POLAND

AERODYNAMICS FOR AEROMODELLERS

by Hugo van Eysselsteyn Kummer

CHAPTER 1

1. Reynolds' number and drag coefficient

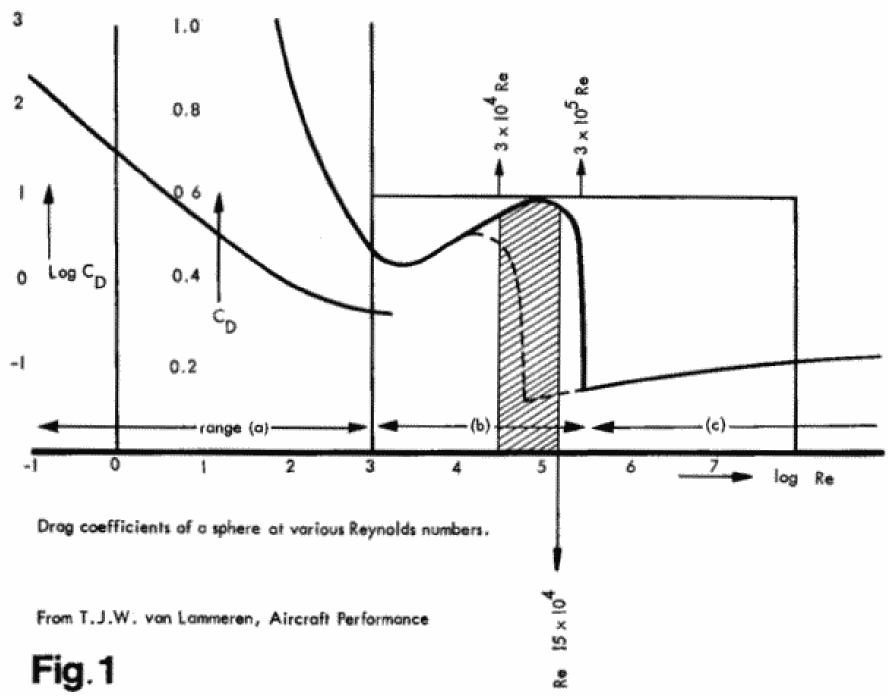
In what way the drag coefficient changes with the Reynolds' number, is drawn in *Fig*. 1 for a sphere. It can be seen that the curve has three ranges.

In range (a), where the logarithm is drawn instead of actual C_D, a decrease of C_D occurs when *Re* increases. As C_D below $Re = 10^2 = 100$ increases very much, the curve has been broken off for the *Re* value and for $Re = 10^{-1} = 0{,}1$ to $Re = 10^2$ the logarithm of C_D has been drawn on the vertical. Thus for $Re = 10^{-0.5}$ the logarithm of $C_D = 2$ and $C_D = 100$.

In range (a) where V is very low, or L (in this case the diameter) very small, or λ (= viscosity) is large, no eddies are generated and no energy is lost in the moving fluid; because there are no eddies the flow is called *laminar*.

In range (b), where eddies and currents are generated and the flow breaks off, an area of turbulence is formed behind the body. Here occurs turbulent flow, a flow with rotating currents. However, the slower moving flow directly against the surface, called *boundary layer*, flows in the laminar way. The formation of eddies does not occur in the same way at all speeds, however, so that C_D is not constant.

After that a singular leap occurs in the C_D curve, and in range (c) the C_D value becomes much less. This sudden decrease of C_D can only be the result of a sudden change in the flow. The reason for this has been found by experiment. It appeared that the boundary layer, having a *larger* kinetic energy, is able to follow the surface longer. It follows that the turbulence behind the body is



Drag coefficients of a sphere at various Reynolds numbers.

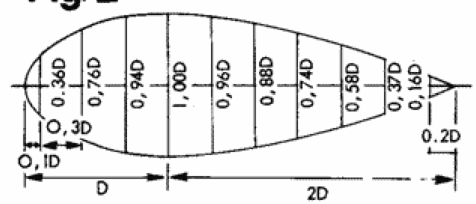
From T.J.W. van Lammeren, Aircraft Performance

Fig. 1

TABLE 1

SPEED	
$V = Kx\sqrt{\frac{W}{A}}$ m/sec. W grams, A dm².	
C_L	K
0·3	2·31
0·4	2
0·5	1·79
0·6	1·63
0·7	1·51
0·8	1·41
0·9	1·33
1·0	1·27
1·1	1·21
1·2	1·16

Fig. 2



Dimensions for the Ideal Streamline.

To obtain thinner section = multiply all verticals by the same factor, and redraw.

TABLE 2

Dimensions of the Ideal Streamline in approx. %

0	5	7·5	10	15	20	25	30	40	50	60	70	80	90	100	
0	3·05	3·85	4·45	5·3	5·9	6·35	6·62	6·55	6·07	5·25	4·2	2·95	1·54	0	a
0	1·22	1·54	1·78	2·12	2·36	2·54	2·65	2·62	2·43	2·1	1·68	1·18	0·62	0	a × 0·4
0	1·52	1·92	2·22	2·65	2·95	3·17	3·31	3·27	3·03	2·62	2·1	1·47	0·77	0	a × 0·5
0	1·83	2·31	2·67	3·18	3·54	3·81	3·97	3·93	3·64	3·15	2·52	1·77	0·92	0	a × 0·6

much less and thus much less kinetic energy is lost. The drag of the body is now reduced and, although the drag in turbulent flow is higher than in laminar flow, the total drag and thus the drag coefficient is lower. The change occurs at *Re* = about 300 000.

This change, however, depends on some conditions. One of these is the surface grain of the object. Often a rougher surface induces a fall of drag at a lower *Re* than is the case when the surface is smooth; the effect is that in spite of the rougher surface a lower C_D is obtained at a certain value of *Re*.

The fall in drag occurs also in the situation where the flow is already turbulent before it reaches the body. The earlier or later occurrence of a fall in drag is therefore a measure of the existence of turbulence in the wind tunnel and therefore its quality.[1]

The occurrence of turbulence may cause a flow that has separated itself from the surface to re-attach itself again, or the turbulence may even prevent separation of the flow at all. Which of these alternatives occurs depends on the Reynolds' number and also on the curvature of the surface behind the point of separation.[2]

2. Reynolds' number and model gliders

All this is pure nature and well known to aerodynamicists, but of course with full-size aircraft only range (c) comes under consideration. Range (a) is called *subcritical*; to all intents and purposes the range 30 000–300 000 can be called *critical* because in this range the effect of surface on flow is not according to expectation and hence C_D is unpredictable.

Of special interest to modellers is the shaded range between $Re = 3 \times 10^4$ and 15×10^4, because it is here where most models operate, assuming that there are only a few models that fly in excess of $Re = 15 \times 10^4 = 150\,000$. Most A2 models fly at around $Re = 68\,000$, right inside the critical range.

It follows that the *complete* model is subject to the Reynolds' number at which it flies. "$V \times L$"[3] does not exist, neither "critical VL", "section critical VL" or other such distinctions. It also follows that a model does not "go sub-critical" and that the geometry of the airfoil is of no consequence, or that increase of V or L necessarily bring about improvements of airfoil characteristics. The airflow does not necessarily break away at normal angles of incidence. To improve airfoil characteristics other means must be investigated; this is the subject of Chapter II, 3 & 4, and III, 7–8.

For all flying models, the Reynolds' number is given as $70 \times V \times L$; V in m/sec, L in millimetres. The number 70 arises from a difficult notion called kinematic viscosity.

Example of *Re* determination for an A1 named "Osborne."
Given: span 125 cm, wing area 15 dm^2, tail area 3 dm^2, weight 225 grams.
Follows: average wing chord 15:12,5 = 1·2 dm = 120 mm and wing loading 225 gr/18 dm^2 = 12·5 gr/dm^2.

In Table 1 we look up the speed formula at a *normal* $C_L = 0{\cdot}6$ which gives $V = 1{\cdot}63 \times \sqrt{\frac{W}{A}}$ m/sec. $= 1{\cdot}63 \sqrt{12{\cdot}5}$ = about 6·5 m/sec. Thus $Re = 70 \times V \times L = 70 \times 6{\cdot}5 \times 120 = 54\,600$.

Example of *Re* determination for an A2 named "Lily 'n Valley".
Given: Wing loading 16 gr/dm^2, average chord 152 mm.
The normal speed will be $1{\cdot}63 \times \sqrt{16} = 6{\cdot}52$ m./sec. Thus $Re = 70 \times V \times L = 70 \times 6{\cdot}52 \times 152 = 69\,160$.

Therefore, in magazine model plans the *weight* of the model should be given. It will be clear that there is no such thing as "critical chord width"; it is the airflow which is critical or not, as the case may be, and the actual chord width in mm has to be calculated into the *Re* formula.

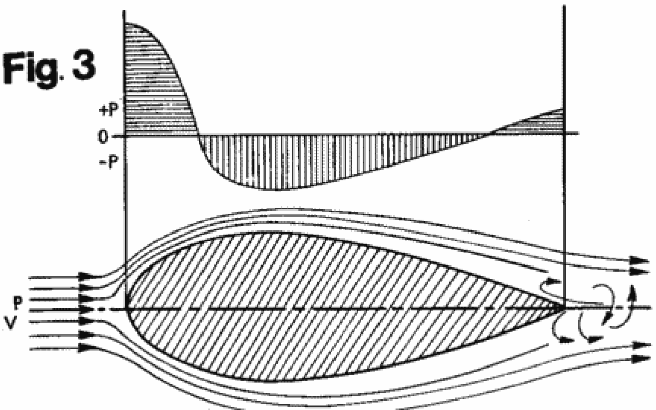
For a model to get out of the critical *Re* range the specifications would be, *e.g.* a wing loading producing a speed of say 17 m/sec and an *average* chord of say 250 mm. It will then normally fly at $Re = 70 \times 17 \times 250$ = just over 300 000.

For its surfaces a highly polished finish may be suggested as an attempt to induce laminar flow over part of them, but the critical *Re* number is most uncomfortably near and only a slight drop in speed may affect performance seriously.[4]

3. The nature of lift

A flat plate held at a positive angle in a horizontal airflow is pushed upwards as a result of the air hitting it and our hands have to push it forward and downward to keep it in position. So far Newton, but not so good because the Newtonian explanation is mechanistic and we are talking airfoils which are in effect *very* complicated. But this is easy to observe, though; hold an ordinary plano-convex sectioned wing exactly horizontally in a horizontal airstream to minimise the air's deflection downwards so as to be negligible, and there is a definite "reaction" upwards; the thicker the airfoil the more "reaction".This phenomenon is called lift and is due to the difference in air pressure above and under the airfoil. Here we have to do with Bernoulli's Law[5] which is of fundamental importance. Compare the pressure charts of the streamline body with Gö 387 (*Figs*. 3 and 4) and notice the patterns of low pressure and high pressure Also notice that the streamline body has its maximum thickness at about 33% of chord. Lilienthal was the first to point out that an airfoil produces more lift with lower drag for the same area and speed.[6]

Fig. 3



Flow round a body with pressure diagram

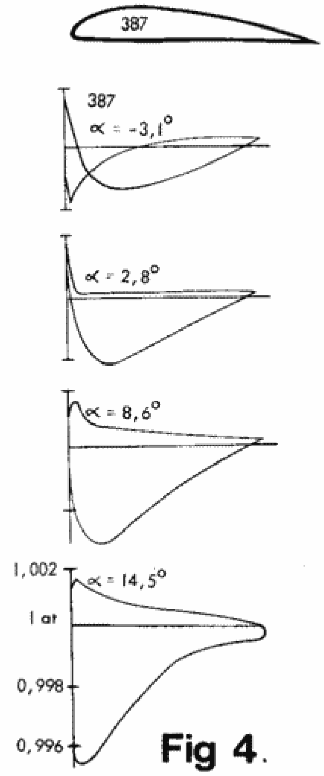


Fig 4.

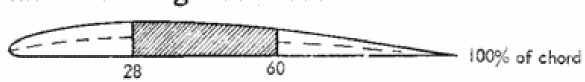
TABLE 3

Gö 387	
α	CP at chord %
−4	70
−2	50
0	40
+2	38
4	33
6	30
8	30
10	31
12	30

There is upwash in front of, and downwash behind the airfoil. The more curved the airfoil, the more of both. After the downwash the air moves upward again to "settle" so that more kinetic energy is lost. The realization of pressure areas etc. led to the mathematical development of "laminar" airfoils[7] for full-size gliders, which we can use for Free Flight but are no better than the ones we use already (see Ch. III. 5).

Methods for calculating the corresponding distribution for an arbitrary airfoil do exist[8]; the problem of finding the profile corresponding to a prescribed pressure distribution could also be solved by a method of approximation[9]; the calculations with regard to viscosity and pressure are of considerable difficulty.[10]

All forces on the airfoil combine to produce a Resultant; the point along the chord on which this resultant acts is called *Centre of Pressure*. In all wings with an airfoil skeleton showing "camber" this CP moves about, also due to buffeting and gusts in unstable air. In a stabilized wing this movement is restricted to 28–60% of chord, see Table 3.



Section showing range of CP movement

In free flight modelling, the CP movement is not a curse but a blessing, because it enables us to form an automatically stable set of forces, by *locating* the CG just outside the range of CP movement, after which a stabilizing couple is formed by a stabilizer and its moment of arms.[11]

When the CG is put at 28% of chord, the stabilizer section is usually symmetrical and then it only stabilizes. When the CG is put at 60% of chord the stabilizer section should produce lift as well.[12]

CHAPTER 2

1. A little Bit of History

BEFORE my teens, and reading popular books on aerodynamics, I tried to explain the airstream breakaway from the wing top surface by reasoning *not* that the flow could not hold onto the curve, but by the fact that the air pressure was lower than that on the underside, so that at the trailing edge the under flow would try to make up for the deficiency by curling up, increasing drag. So much for a simplistic approach! In our club we were only dimly aware that there was a *boundary layer* involved. After all, the *Me 109* and soon after that the *Typhoons* and *Mustangs* did not seem bothered by too much drag, viewing their antics when they shot up the railway yard near by. For our models we used rather thick sections like Eiffel 400, NACA 6409 and 6412, Gö 497, 500, 501 and we rigged the angle of attack at an all-purpose 3°, which is about halfway between zero lift and stall.

2. Two basic rules

Flying in fine weather we tried to increase lift by increasing the angle of attack through trimming, according to the following two basic rules:

(a) L/D max occurs when the wing flies at a small angle of incidence θ. At the smaller θ the C_L is lower. To obtain the same lift the speed must be higher.

In this case the speed is about 2,1 $\times \sqrt{W/A}$ m/sec.

The result is that the model travels faster per time unit.

To arrive at this result the elevator's TE must be down trimmed.

(b) L^3/D^2 max occurs when the wing flies at a large angle of incidence θ. At the larger θ the C_L is higher.

To obtain the same lift the speed can be lower.

In this case the speed is about 1,3 $\times \sqrt{W/A}$ m/sec.

The result is that the aircraft sinks less per time unit.

To arrive at this result, the elevator TE must be uptrimmed.

We looked at the gulls around us. When landing they opened some of their primaries as slots to increase lift when stalling; by pulling muscles, the outer panels of their wings remained more or less horizontal, while the inner panels stalled. When circling in a thermal you could see them fanning out their wings to the utmost to bring down their wing loading; probably they pulled some more muscles to change also the angle of attack for best C_L^3/C_D^2. It was inimitable.

I considered the mere dimension of the model's wing section, chord 10–12 cm, an obstacle to better performance, and reasoned that the sheer curve of the section was too pronounced, generating too much drag. Yet those gull wings were not much broader and they seemed to manage perfectly well. Somehow better performance should be possible not by increasing lift (and then having having to repair the model every other time because it would stall too quickly and not recover) but by reducing drag. But I could not figure out how exactly this could be effected.

3. Discovery by accident

Then, summer 1944, two articles appeared in the national aviation magazine about Schmitz's discovery by accident[13] which happened a few years before. It was the first article in which the Reynolds' number was given as a

TABLE 4

		0	1·25	2·5	5	7·5	10	15	20	25	30	40	50	60	70	80	90	100
NACA 6409		0	2·06	2·95	4·3	5·4	6·3	7·8	8·9	—	10·15	10·35	9·8	8·8	7·9	5·35	2·95	0
		0	0·9	1·1	1·2	1·1	0·9	0·35	0·15	—	1·1	1·65	1·85	1·9	1·75	1·35	0·75	0
	sk	0	—	0·7	1·4	2·05	2·65	3·65	4·5	5·2	5·6	6	5·85	5·4	4·55	3·3	1·8	0
	r	0	—	1·6	2·55	3·15	3·45	3·9	4·2	4·4	4·5	4·3	3·9	3·45	2·7	1·85	1	0

point of departure in assessing the flying characteristic of models. So that was what it was: *our model gliders were aerodynamically related to birds.*

Profile drag was seemingly reduced by the use of fairly flat concave airfoils of 4–6% thickness. After the liberation in 1945 we hunted the model press for these thin airfoils and we used Gö 123, 381, 373, 375, 396, 417, 488 and 499 and the more daring amongst us designed our own airfoils. It seemed that we got more lift, but we also seemed to get more drag, especially with the more curved concave airfoils, but that was not the point! (See Section 6, page 104, "The model that Schmitz gave . . .")

4. Experiments

During the "fifties" I built an A1 *Aiglet*, but instead of using the wing section as per plan (MAP) I used the eagle section, of which I designed four varieties. The lift-producing elevator section was very thin and slightly concave. This model was an enormous success and a great stimulus to club life. At the following regional meeting the D/T failed on the first flight; I got my one max and was classed about halfway down on the list of a dozen entries. This was promising. See *Fig.* 5.

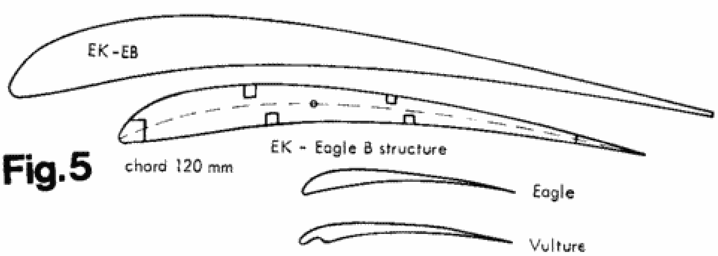
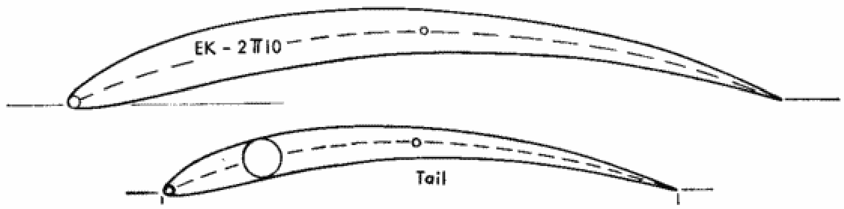


Fig.5

TABLE 5

		0	1·25	2·5	5	7·5	10	15	20	25	30	40	50	60	70	80	90	100
EK-EB eagle		1·25	3·85	5·35	7·2	8·6	9·6	10·9	11·6	11·9	11·8	11·2	10·1	8·7	7·05	5·05	2·75	0·2
		1·25	0	0·1	0·65	1·2	1·75	2·8	3·8	4·6	5·1	5·65	5·6	5·05	4·05	2·85	1·45	0
	sk	0	—	2·2	3·6	4·7	5·6	6·85	7·7	8·25	8·5	8·4	7·9	6·9	5·5	4	2·1	0·1
	r	0	1·25	2	2·85	3·35	3·7	3·92	3·9	3·65	3·3	2·75	2·2	1·8	1·5	1·05	0·6	0
EK-2π 10 "Joukowski" arc		0	—	2·75	4·25	5·6	6·75	8·5	9·8	10·8	11·5	12·3	12·25	11·3	9·1	7·15	4·05	0
		0	—	0·75	0·5	0·2	0·25	1·2	2·2	3·25	4·2	5·75	6·65	6·8	6·25	4·85	2·75	0
	sk	0	—	0·9	1·6	2·6	3·4	4·75	6·1	7·15	7·8	9	9·4	9	7·8	6·1	3·4	0
	r	0	—	1·6	2·3	2·75	3·1	3·6	3·73	3·71	3·65	3·28	2·83	2·25	1·65	1·1	0·6	0

Fig. 6



Attention is drawn to the laced-in nose portion of the vulture section, that also appears similarly in crane, stork and flamingo. Modern airfoils showing this feature at B8406, Eppler 387, the B655X and an extreme one from Gremmer. According to Schmitz[14] the optimum range of maximum skeleton camber lies between 15 and 25% of chord; this compares favourably with bird wing sections.

Concurrently I designed airfoils to *Joukowski* specifications and incorporated one in an attractive and safe-looking A2 design by Carlo Varetto (see Zaic's Yearbook 1955/56). The sheer height of the section was arresting (18 cm. chord). its profile drag would compare poorly with Gö 497 or NACA 6412, so I thought. See *Fig*. 6.

The wing was rigged at a "conservative" angle of 5° and would produce a C_L in excess of 1·2. The model was "nervy" as are most world champion A2 entries. Speed 4–6 m/sec, elevator section also 2π 10.

I designed a programme to investigate systematically the boundary layer and turbulence, knowing the wing would be spoilt in the end. After every change of surface I towed the model up four or five times to obtain consistency of performance, then grabbed pad and pencil and jotted down what I saw 50 metres up. Upper rough, lower shiny produced the most disconcerting note: contrary to expectations the model just sank down, every time just about a minute's flight. Both surfaces shiny: even worse. Then shiny surfaces with turbulators, quickly pinned on at 5, 10, 15, 20, 25% of chord: no improvement to speak of. Trying rubber turbs in front of airfoil proved only that my patience was tried well—despairing business—in any case I could not discover any bird with rubber turbulators; not that I saw any of the club A1 or A2 gliders feeding or being auto-reproductive either! Quite a bit of time was spent in gluing an extra nosepiece on, then sanding it down to sharp nose radius—it led to further deterioration of performance, not very noticeable, but the chronometer told the story. Fixed turbulators brought some improvement, oddly enough.

This harangue of six months' work for fun ended with reconditioning of the wing to its original state, shaping the L.E. again and soaking off all the trouble, using medium drawing paper for a torsion free nose, medium tissue for the rest. Three coats of 25/75% dope/thinner as of old; with extreme care the drawing paper responded (a far from ideal covering, it tears most unexpectedly). In this state the Varetto has been flying beautifully for almost 12 years with an average sink of just under 29 cm/sec. It was the old story but with a new difference: an all-purpose NACA 6409 can be trimmed for L/D max *or* for L^3/D^2 max; to improve L/D a thinner flatter airfoil is needed. The new difference was that for L^3/D^2 max a highly curved airfoil was the special thing, and the EK-2π 10 was evidently one of them.

So I proved to myself that an almost matt looking, slightly rough surface, although unattractive, could reduce the C_D of wing and elevator, which made me think of the elevator's *Re* number. One rainy day I had a beautification quirk and Humbrolled the long slender fuselage gloss white. After that the aircraft would not respond to the rudder, so I sanded off most of the enamel. The airflow along the fuselage must have been affected by the glossy surface.

5. More birdwing and Joukowski airfoils

A few years ago another *Aiglet* was produced with the same Eagle B airfoil, same for the tiny elevator; this version also proved highly successful. A point was made of keeping all surfaces including fuselage and fins/rudder, matt by covering with light tissue and giving them only 3 layers of 25/75% dope/thinner. I refrained from polyurethane matt varnish, because it is heavy, and because it looks matt, but in fact gives an extremely silky and smooth finish.

In the same period I developed a $\frac{1}{8}$ scale design of a wing coming out at 2·54 m span and I built (M-Exp.) with the EK2π 10 airfoil, the other (M-Proto) with the Eagle airfoil EK-EB. Both models were designed with great directional stability in mind, so that the fuselage could not be made to scale but were elongated to give a long moment of arm of front keel and fin. The first of these turned out very light and flew extremely slowly. It had no penetration to speak of but it was a joy to watch it airborne, minute after minute head into wind 30 metres up in the hill lift of the puffing up and dying down evening air.

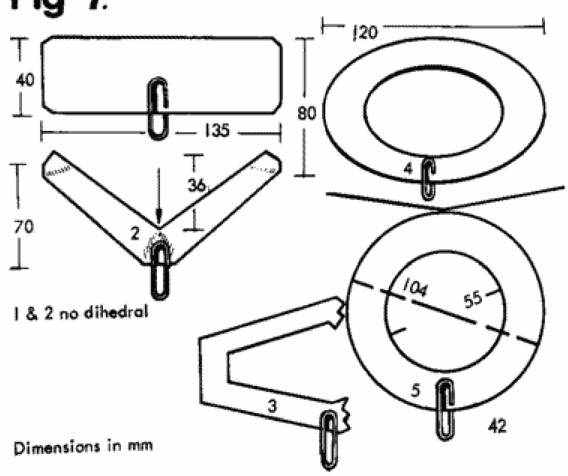
Its companion was built on the heavy side because it was meant to fly faster, with less directional stability but with a corrective electro-magnet steering gear, for which I allowed 100 grams inclusive of miniature batteries. As all directional stability problems were solved with the first one there was no reason to doubt its performance, but the actual building of the miniature circuitry stopped halfway. A subsequent development of this design, now everything to $\frac{1}{7}$ scale and wing span 2·88 m lead to the incorporation of multi R/C and despite hardly sufficient penetration should be able to pick up a thermal off the hill. On a couple of outings it has shown that it refuses to come down in 6-knot winds up a gentle slope.

6. Comments

Since the discovery of Schmitz we know that the Reynolds' number is of prime importance in assessing a model performance, but that does not mean that what happens to the airflow in the subcritical or critical region was unknown. Subcriticality is not caused, *it just happens.*

A paper flyer (*Fig.* 7) made of drawing paper and fitted with a paperclip

Fig 7.



Van Hattum paper models

for balance, flying at 4 m/sec. with an average chord of 40 mm flies at $Re = 70 \times 4 \times 40 = 11\,200$. Its drag is pretty high at that number, never mind its induced drag, in relation to lift and span. It literally cuts through the air and the airflow is laminar. It is left to the reader to try one out and determine its wing loading, average chord, speed and *Re* number. Don't forget the paperclip; launch it gently at an angle of 1°; stability can be influenced by moving the paperclip slightly forwards or backwards. Trimming takes quite a while, once trimmed they fly excellently.[15]

In case of A1 or A2 the airflow is critical, i.e. the model flies at a *Re* between 3×10^4 and 15×10^4. This means that normally the drag is high and that the speed is not quite what we expect it to be from the wing loading; it always seems to fly slower or sink quicker. It also means that there are certain external circumstances which may reduce the drag, to our surprise and gratification.

Most modellers experience those feelings when their model one day suddenly begins to fly "better" but most of them have no idea what the causes were. One such cause could be that they hung up their glossy pride in the sitting room, left it for a week and—an invisible layer of dust collected on the surfaces.

The model that Schmitz gave to a beginner to repair was returned and repaired, but how! The paper sagged between the ribs, the nicely half round bulbous wing section nose was now sharp in comparison and the new covering was anything but smoothly finished. Lo and behold, this slapdash repair job flew *better* than ever before. This paradoxical effect was investigated at length and eventually Schmitz advocated the use of **(a)** thin airfoils with **(b)** small nose radius, because respectively **(a)** model wings belong to the same category as bird wings **(b)** the small nose radius evidently generated the turbulence that brought about a fall in drag.

In the course of time the third item has been mentioned only very occasionally; it appears once in the 1944 article, and Max Hacklinger touches it in passing in *Avia* (1955). It is most likely that the chapter called "*The Nature of Drag*" was simply forgotten in the general rush for the coordinates of thin airfoils.

CHAPTER 3

A SUMMING up of so-called theory and practice should make the following points concerning model aircraft and their airfoils.

1. Analysis of Performance

Analysis of performance is directly related to the wing and its airfoil, whereas all other parts of the aircraft must pass a scrutiny as to whether they add to that performance (power) or detract from it. In the case of model gliders the following list can be drawn up; investigating the properties of the wing as the most important element a number of models should have *the same*:

(a) rigging
(b) C.G. location
(c) geometrical layout of tailplanes
(d) elevator airfoil
(e) elevator trim
(f) elevator moment of arms
(g) profile drag
(h) chord width and span
(i) wing loading
(j) surface finish

Group g–j is directly related to the Reynolds' number which must be the same.

The items (a) to (j) provide 165 combinations, all reasons why a model may not attain absolute maximum performance, and the possibilities in airfoils and/or the surface finish have not been exhausted. Therefore, a statistical analysis of 21 A2-gliders based on rate of sink/aspect ratio *only*, as conducted in *AMA* 1970/71, and any conclusions drawn from it, must be viewed with extreme reserve. Further deductions from these conclusions, based on a sizeable number of basic misconceptions and inaccuracies as appears on pp. 22–34 of *AMA* 1973/74 are not convincing and cannot be taken seriously.

Example of aerodynamic factors involved

If, in an attempt to increase performance, the aspect ratio is altered, not only the induced drag is going to change but also the effective angle of incidence so that a new trim must be sought. This new trim must be converted into a new rigging to effect the new angle of incidence. This change of angle then produces a change in profile drag which in case of symmetrical and biconvex airfoils is negligible but in case of highly concave airfoils may run into several percentages. Profile drag (g) is directly related to Reynolds' number and can only be determined by experiment in a low speed wind tunnel.

2. **Angle of attack and efficiency**

The angle of attack is either rigged or trimmed, a distinction that is not realized in many modelling quarters. There is a choice here between L/D max, L^3/D^2 max or "all purpose" ("all weather").

L/D max of most slightly concave and plano convex airfoils occurs somebetween $\alpha = 0°$ and 5° and a good average is 3°. The wing should be rigged at that angle and the model then trimmed to fly with the fuselage horizontal; only then can one speak of an efficient use of that airfoil.

However, L^3/D^2 max is obtained in excess of $\alpha = 5°$ and may be as much as 9°. In that case the above named type of airfoil is rigged at $\alpha = 5°$ and over, the model is then trimmed to fly with fuselage horizontal; only then is it possible to speak of an efficient use of that airfoil.

The thicker concave airfoils of the type NACA 6412 with their fairly large nose radius can stand this kind of treatment, because they do not stall straightaway at the larger angle, nor does their C_D suddenly increase at the smaller angle.

In flight the fuselage must be horizontal because (a) if it is not its drag is impairing the best L/D or L^3/D^2 that was aimed for, (b) the observer needs a visual check that the rigging is in fact attained. Please note that the above is on the assumption that the model flies in a horizontal airstream and also that zero incidence is measured from the straight that connects the centre of the nose radius with the trailing edge, *e.g. Fig.* 8, airfoil (f).

Fig. 8a

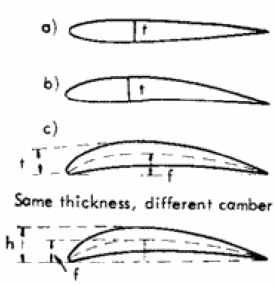
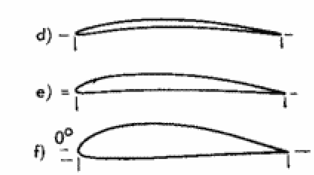


Fig. 8b



some skeleton, different thickness

The thin airfoils with sharper nose radius are limited in range; they are in effect "special" airfoils because they are not "all purpose". Of the thin variety the flatter ones produce a good L/D because their profile drag is low; they should be rigged and trimmed at $\alpha = 2°–3°$ and they are unsuitable for duration flight. The highly curved ones have a poor L/D because their profile drag is higher; rigged and trimmed at an angle of 5° they have not even reached their optimum L^3/D^2 so they are in fact only suitable for duration flight.

E.g. the "special" HE-105S should not be used for "all purpose", it is not meant to produce much lift or a minimum sink; the "special" B6557-b should neither be used for "all purpose", it is not meant to produce speed or a fantastic L/D.

The aforementioned A1 "Osborne" is having a new wing, same dimensions and dihedral, but now with a "special" highly curved airfoil. At a rigging of 5° or 6° this airfoil may produce a C_L of about 1·1. Consulting the speed table its speed will be $1{\cdot}2 \times \sqrt{W/A}$ m/sec. $= 1{\cdot}2 \times \sqrt{12{\cdot}5}$ = about 3·8 m/sec., considerably slower than "Osborne I". The Reynolds' number is now also lower: $70 \times 3{\cdot}8 \times 120 = 35\,280$. Checking this value in *Fig.* 1 this number indicates that the good performance aimed for may be obtained, since it will fly within the critical range, but only just. This is a reason to pay particular attention to the surfaces of the model. See Section 8 of this chapter.

3. Airfoil thickness

The airfoil can be made very thin and sometimes this is necessary. Schmitz introduced a measure for thickness at given *Re* numbers, showing a linear increase:

Re	t
0	0
50 000	3
100 000	6
150 000	9
200 000	12% of chord

These figures should not be taken too literally, they are rather good approximations. However, there is very little relationship between profile *thickness* and drag, consider *Fig.* 8a. In airfoil (*a*) profile drag has almost disappeared, its drag consists of skin friction. But in airfoil (*c*) there is not only more skin friction because of the longer upper curve, but also an appreciable profile drag, *due to the camber*. The height *f* of the skeleton or "mean camber line" is taken as reference, not the height *h*. It may come as a surprise that no satisfactory formula has been found to relate profile drag to either thickness or skeleton or both[16]; in the meantime it is the skeleton—max *f* that accounts for the profile drag. We can think of improving one of them by thinning, which is often done, *e.g.* multiply all ordinates of upper and lower of NACA 6409 with 0·6 and an airfoil of about 5·5% thickness obtained. It looks "sagging" compared with the original well-tried one, but what has been done exactly? The L/D has been improved somewhat, but the original characteristic of low sink at a larger α has been impaired, because the original skeleton has been "factorized" in the process. This is the case against such treatment. Better leave that skeleton alone, it is the "soul" of the airfoil; there is much room for other experiments, see Section 5 of this chapter.

Birdwing sections show maximum thickness between 15 and 25% of chord; EK-EB has t-max at 16%. Comparing the wing sections of willow warbler (chord 4 cm.) with eagle (chord 28 cm.) the actual thickness per cent becomes almost meaningless; the former bird wing gives 2·5%, the latter is much thicker than its chord would suggest, and is in the region of 8·5%.

In soaring flight some airfoil thickness evidently must be retained for the (unknown) optimum pressure distribution.

4. **Nose radius**

The nose radius is rather important. Some chuck gliders have noses simply sanded round (Suzy Q), some have parabolic shape, others knife sharp edges. For A1, A2 and many Wakefields the usual minimum is about 0·9%. Benedek 6556-c and 6557-b specify 0·6%. These numbers are a bit suspicious because with a 25-cm. chord the nose is nicely rounded but with 10-cm. chord it is decidedly sharp, although not pointed.

The air should be helped to adhere to the wing's surfaces but without polar diagrams from wind tunnel tests it should be left to the air to choose the surface over which to flow and make its own pressure diagram until the time that more information becomes available.

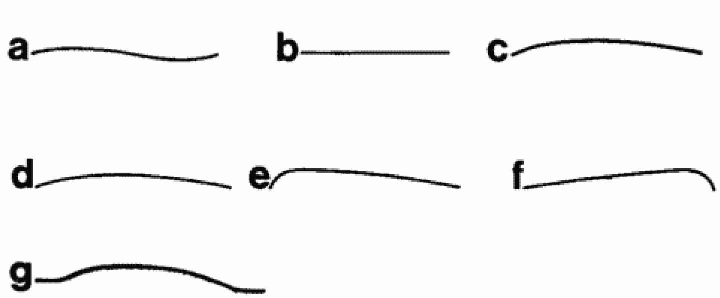
With a chord of 12 cm. for A1 I design the nose radius to about 1·6%, for A2 and larger the radius becomes 1·2–1·3%. The sharper nose radius was tried in a variety of models with detrimental effect on performance. Make aluminium templates to the exact radius for checking. Prop the wing up to an exactly horizontal datum line and design the template with a bottom edge to correspond with the datum line. You will soon have half a dozen reliable templates.

5. **The model glider airfoil skeleton**

To the casual observer, there may be a relationship between size and curvature of the airfoil on the lines of: the lower *Re* the less curve, but there is no such connection. The airfoil skeleton-*max* point may be anywhere along the chord, and that's the rub: where? In *Fig.* 8B the same skeleton is used and also the *same* streamline (the radii of (e) and (f) are 2x and 4x those of (d). Airfoil skeletons in every imaginable form have been investigated since Lilienthal, *e.g.* those forming an arc of circle (because the drag can be calculated exactly). combinations of intersecting or touching arcs, combinations with straights, paraboloids such as bird wings have and combinations of them.[17] Literally thousands have been discarded through the requirements of powered flight because of undesirable CP movement in most of them.

There are 3 types, see *Fig.* 9.

Fig.9.



(a) "S" type; *e.g.* N6OR; an increase of α is "corrected" by rearward CP movement
(b) flat and symmetrical; CP lies at or near 25% chord
(c) curved with "camber", common in everything that is entitled to fly.

Types (b) and (c) need a stabilizer.
Type (c) has 4 varieties

(d) perfect arc (Joukowski), CP movement 28–50%
(e) bird
(f) flap
(g) "double S" small CP movement in the region of 27%.

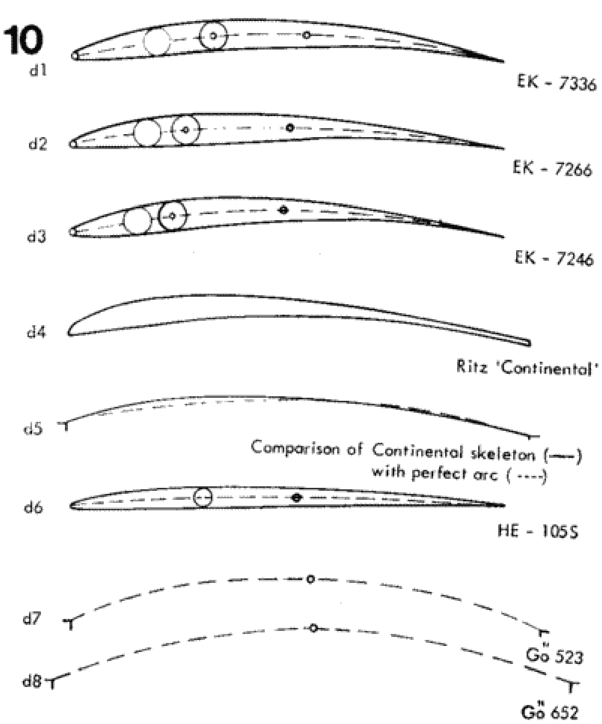
Notes. (See *Fig.* 10)

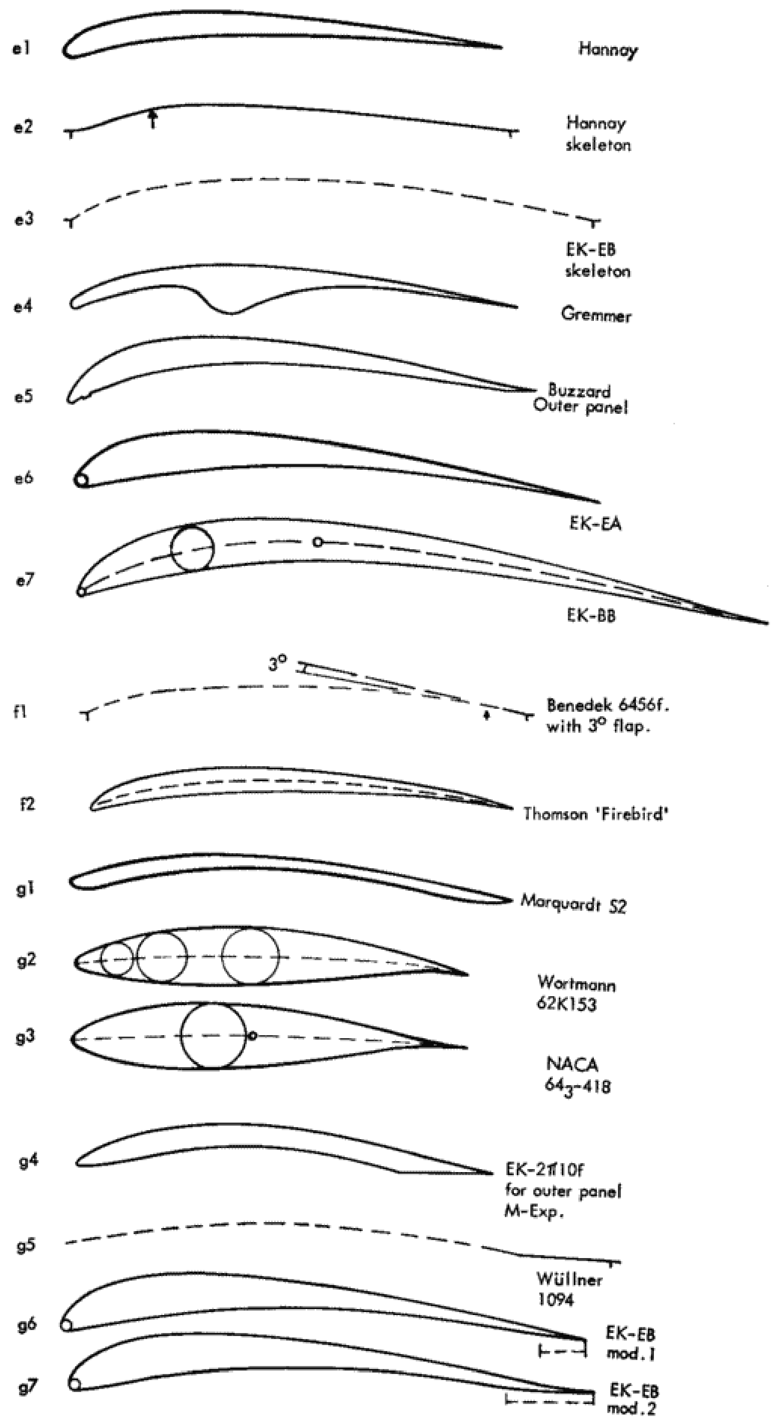
On variant (d). Airfoils based on the perfect arc are comparatively rare in modelling. Three sections are given in (d1–3) and one in *Fig.* 6. In (d2) and (d3) the "ideal streamline" has been manipulated in order to move the maximum thickness forward, thereby making them more suitable for duration flight.

Small departures from the perfect arc are very common. These can be observed in Ritz "*Continental*" (d4 and d5) for duration and in HE-105S (d6) for speed. Also the skeletons of Gö 523 and the famous Gö 652 (d7 and d8) show slight departures from the perfect arc.

The more the skeleton approaches the perfect arc the more the CP will start moving forwards from about 50% of chord, instead of 60%, at zero incidence. In case of an ordinary rectangular wing stabilized with a lift producing stab one consequence of this is that the CG can also be located at about 50% of chord. This is a safe location on the condition that the wing is rigged and trimmed to fly at the larger angle for duration. Flying at the smaller angle can be lethal,

Fig. 10




e1
Hannay
e2
Hannay
skeleton
e3
EK-EB
skeleton
e4
Gremmer
e5
Buzzard
Outer panel
e6
EK-EA
e7
EK-BB
3°
f1
Benedek 6456f.
with 3° flap.
f2
Thomson 'Firebird'
g1
Marquardt S2
g2
Wortmann
62K153
g3
NACA
64_3-418
g4
EK-2π10f
for outer panel
M-Exp.
g5
Wüllner
1094
g6
EK-EB
mod. 1
g7
EK-EB
mod. 2

for if a disturbance suddenly lifts up the tail the CP may easily move behind the CG, resulting in the notorious "dive in" without redress. "Aero Modeller" usually reports these mishaps. Such a "sharp" setting is not recommended.

On variant (e). The drawings show birdwing sections and derivations with strongly curved paraboloid skeletons which are very birdlike and extremely rare in modelling. Hannay (e1) is a remarkable airfoil and a good example, showing in its skeleton (e2) an odd kink at 20% of chord; the birdlike streamline is absent though. The coordinates of this successful design are given in Table 6. Notice that the Eagle skeleton is much more regularly curved (e3). Gremmer's section (e4) which was used in a model with only 5 gr/dm² wing loading, shows two very strong curves in its skeleton; compare this with the Benedek section (f1) which has two very moderate curves.

Section (e5) was taken from a buzzard just after its last flight, hunting a rodent that ran across the road. The strong curvature should be compared with the original Eagle A (e6) with its very thin rear half. The buzzard section was developed (e7) for an A2 as EK-BB, see Table 6.

On variant (f). A real flap is rare in modelling, because the airfoil skeleton needs a kink downwards of at least 2°; without the kink there is merely a continuous skeleton curve. Gö 417 as in Thomson's *Firebird* is not really flapped (f2); B6456f in (f1) shows a kink of 3° and is effective. The Wortmann section (g2) has a continuous skeleton curve and what looks like a flap, but isn't, is contrived by skilful design of the streamline radii.

In A2 the point of flapping an existing section is not clear, unless the flap can be moved to suit various weather conditions; a similar section with a bit more camber has the same effect. In Wakefield an extra notch on the timer can actuate a sprung flap after the ascent. In R/C the flap is movable and can be set for speed, cruising or braking, and that's what makes a flap. To be at all useful and effective the entire flap hinge must be sealed.

On variant (g). The "double S" was developed in the '30s as a variant of the Joukowski arc; by raising the front and rear portions of the skeleton it was found that the CP moved very little. For years it was used in Wakefields and Marquardt S2 (g1) is typical.

A bit more common is the raising of one skeleton end only. In the Wortmann section (g2) this is done only very little, in the NACA section the straight beginning takes up about 5% of chord. "*Cloudmite*" for rubber power (*AM* June 1970) shows the same feature, but is ineffective.

Two variants of type (a), also called "reflex", are drawn in (g4) and (g5).

TABLE 6

		0	1·25	2·5	5	7·5	10	15	20	25	30	40	50	60	70	80	90	100
Hannay		*1·8	*2·9	*4	*5·8	6·8	*7·5	*8·8	9·7	9·95	10	9·7	8·6	7·35	6	4·4	2·6	0·5
		1·8	0	0	0·4	0·9	1·4	2·5	3·4	3·8	4	4·1	4	3·6	3	2	1	0
	sk	0·8	—	1·9	2·9	3·8	4·6	5·7	6·5	6·9	7	6.9	6·3	5·45	4·45	3·2	1.8	0·25
HE-105S		1·25	2	2·42	3·1	3·52	3·87	4·4	4·72	—	5	4·9	4·55	4·17	3·27	2·37	1·25	0
		1·25	0·74	0·57	0·37	0·25	0·2	0·1	0	—	0·02	0·07	0·12	0·17	0·22	0·2	0·15	0
EK-BB buzzard		1	3·25	4·5	6·45	7·8	8·85	10·3	11·35	11·8	12	11·7	10·5	8·85	6·75	4·45	2·1	0
		1	0·05	0·4	1·35	2·2	2·9	4·05	5	5·7	6·1	6·45	6·2	5·35	4·1	2·55	1·1	0
	sk	0	—	2·12	3·65	4·8	5·85	7·2	8·1	8·7	9·05	9·05	8·3	7·1	5·4	3·5	1·6	0
	r	0	—	1·65	2·25	2·6	2·8	3·05	3	2·95	2·9	2·6	2·1	1·7	1·5	0·9	0·55	0

* *Doubtful %. Suggested are* 0·8/3/4·1/5·7/6·8/7·7/8·9/9·7/etc.

To obtain a limited CP movement a displacement rearwards of the "S" was tried out in the '50s. (For the memory, in the proper "S" type Clark YH, $\alpha=2°-10°$, the CP moves 32–27%.) An extreme limitation of CP movement as in Clark YH was not expected, but the kink appeared effective and the CP seemed to move between 40% and 27% of chord. Experiments with two Eagle sections showed that the first modification (g6) was ineffective. The second one (g7) was used in an A1 and allowed ballasting to bring the CG forward (as with (g4) with marked effect on directional stability; one of the two fins had to be removed to make the model turn; this meant a reduction in "wetted area" and a reduction in total drag. Such modifications are apparently only effective if they take up 10% or more of chord.

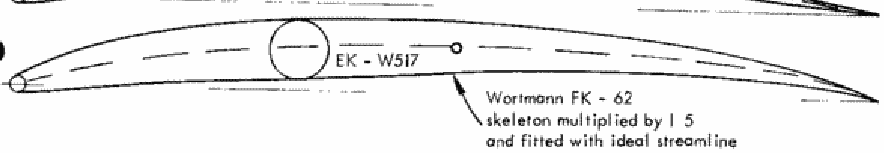
In full size practice surface contours are designed around the skeleton, with regard to pressure, density, viscosity and speed, by drawing circles of which the radii represent some streamline. NACA 6409 shows an almost ideal streamline. NACA 64_3-418 a slight departure and Wortmann an essentially new streamline. Both skeleton-max and streamline-max were brought more to the middle of the section; fibre-glass construction allowed a near-perfect reproduction of the section design and together with polishing the surfaces cased a reduction in drag at $Re = 10^6$ and over, with the airflow becoming laminar over much of the surface, leading to a grandiose improvement of L/D ratios.[18]

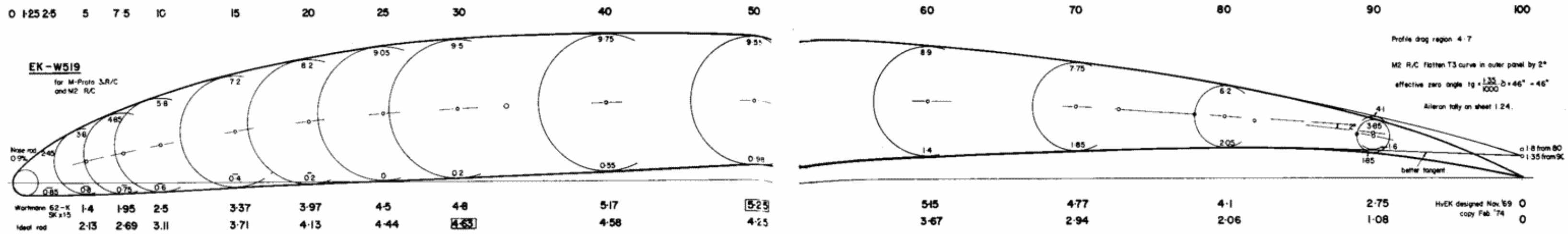
Can we use these new skeletons and streamlines? Yes, with possible improvement in L/D and subject to surface grain. Can we use them for duration? No, because they were not primarily designed for minimum sink at a low *Re*. Compare the Wortmann skeleton with Gö 652 or 523. Draw the Eppler 387 skeleton and notice the minimal difference with an arc of the same 3·6% height. Draw the Eppler 387 radii and notice the *slimmed* rear half compared with the ideal streamline. For minimum sink we should consider the skeletons and streamlines given by the wing sections of soaring birds. As some A2 airfoils show a combination of arc and birdwing skeleton it is certainly worthwhile to explore the skeleton geometry suggested by these two. A formula is unlikely to appear. Skeletons of airfoils in general use are usually successful; these should be kept as they are, and when altered (multiplied) should be compared with existing ones.

Also the streamline geometry must be considered. The Ideal Streamline is not likely to pay off much in this respect; maximum thickness could be in the neighbourhood of about 40% for L/D and between 15 and 25% for duration. Designing streamlines is difficult; one always starts with those that are effective in practice and therefore in the tables an extra column ("r") is given; their ordinates can be multiplied by some small factor for thickening or thinning without upsetting their character.

Fig. 11a

Fig. 11b





Example 1. Design to an easy scale (metre is most accurate, 50 cm. with millimetre grid is handier, smaller is only approximate) the Hannay skeleton (see Table 6); now draw circles around the skeleton at the usual stations using the Eagle B radii from Table 5; lastly draw the upper and lower surface lines touching the circles, see the sketch. The result is drawn in *Fig.* 11a). This is a high performance airfoil for duration, thicker than the original Hannay, not as extreme as Eagle B but generating more lift than Ritz "Continental". Since there are dozens of possibilities it should be registered, Hannay sk. 7% high with Eagle streamline making it 8% thick: EK-H7E8.

Example 2. Same procedure with Wortmann skeleton and Ideal Streamline. The Wortmann 62-K is originally an airfoil for speed with skeleton-max only 3·5%. To investigate its capabilities for minimum sink the ordinates of the skeleton are multiplied by factor 1·5, making the double-arc structure more pronounced. An ideal streamline with maximum radius 3·35% is now fitted and *Fig.* 11b shows the result. This section, EK-W517 reads speed but also quite a lot of lift and should be used for duration.

Example 3. The *ideal streamline itself* makes a very good skeleton. Superimpose on it the Eagle B radii and the result is an airfoil for duration, see *Fig.* 11c and Table 7. Its registration is EK-16E8; the skeleton is 6·7% high and the airfoil is 8% thick.

The interplay between skeleton and streamline requires the greatest care, *e.g.* do not think that a "speed" skeleton can be combined with a "duration" streamline.

6. Turbulence

Between $Re = 3\times10^4$ and 3×10^5 turbulence should be generated to induce a fall in drag, so that both L/D and L^3/D^2 are improved. Hacklinger fitted his model MP–11 with rubber turbulators and experimented in a large hall. The results are given in *Fig.* 12. Rubber turbulators increase drag but the fall in total drag is considerable so that L/D is improved. However, turbulators enable the wing to fly between $\alpha = 6^\circ$ and 9° before stalling so L^3/D^2 is much improved by their use with the wing flying between those angles.

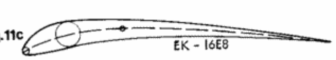
One should be able to do away altogether with turbulators, fixed turbs or those ugly zig-zag cuts along the leading edge.

7. Surfaces — a lesson from the birds.

It is an incontestable fact that wing surfaces should be rough, and now you won't be classed in a *concours d'elegance*! How rough is another matter.

Wings of soaring birds like kestrel, buzzard, gull and albatross show differences between upper and lower surface. The upper surface is hardly shiny at all, it is almost completely dull, warm to the touch, a bit plushy but with a very fine texture. When you look from wing root to tip it shines a bit, but looking the other way it is absolutely matt. The underside is quite different, it looks shiny whichever way you look, but not glossy, cool to the touch and resembling silk. Touched with the finger the upper side is incomparably smooth and soft stroked outwards, stroking inwards upsets the grain, which is only barely perceptible with the finger nail. The underside is decidedly more slippery and the finger nail easily perceives the grain of the elements, about 3 to the millimetre in a buzzard or gull wing.

The upper side is a continuous curved line that at the TE ends in the last feather elements, which are so thin that in flight they are bound to curl upwards; some specimens show this curl built in. On the underside near the LE the curve is broken by the protruding shaft of the first primary, and immediately afterwards is a slight bulge. The section curve is generally retained along the wing span, but of course in flight bending takes place. Note that the tail feathers have the same difference in texture between upper and lower surface.

Fig. 11c


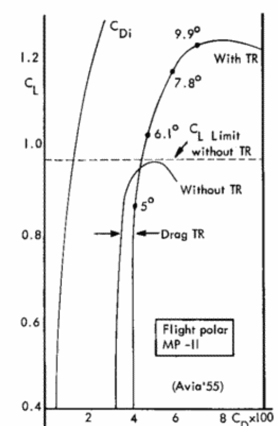


Fig. 12

The nose radius of the inner panel is not sharp at all, for the gull 2–3 mm. radius, it becomes sharper in the outer panel and towards the wing tip.

All these birds fly at critical *Re* numbers.

8. **Surface finish in practice**

Everybody thinks, or so it appears, that giving the model a pint of dope will improve its flying characteristics, it *looks* so good, doesn't it? but considering the surface finish of any A1 or A2 we can start with the observation that wood, silk, nylon or tissue treated with undiluted or half diluted nitro-cellulose makes the surfaces completely mirror like, and the model flies then *as if it were pressed down*. This can be seen in any contest or home outing and it is so normal that modellers don't even see it any more. Last year in a R/C soar-in the depressing effect of "Solarfilm" could be observed. The guided missiles shot along the hill and after a number of heats I seemed to notice one that did not behave like the others, so I watched out for it. Every time it entered it seemed to fly higher than the others. After the game, I asked its builder whether he had made it fly differently from the others, and got the reply "*No, it just flies that way*." Inspection of the machine showed that it was the only one of the group that was covered with tissue and there was no high gloss as on the others.

Hacklinger investigated the results of roughing the upper surface up to 33% of chord, and wrote: "The means employed will only promote the airflow tearing off and a consequent rise in drag." Of course he is right, because when the airflow is going to break away it is going to happen behind 33% of chord where it is most likely to happen anyway. He should have roughened the complete upper surface but of course one is afraid of spoiling wings.

In order to keep the turbulent airflow attached to the layer of air next to to the skin it makes sense to treat the complete surface, a question of imitating our aerodynamic friends and relations. All that is wanted really is a surface with a "key" for the air to hold on to.

During an overhaul on the Varetto I used the rough side of some light typewriter paper and on another occasion I tried various kinds of drawing paper because it bends to shape so nicely. The doped (with thinner) results were not satisfactory. Sheeted surfaces are a problem; when sanded and doped they shine like Paris at night, need sanding with "flour grain" sandpaper, and the airfoil may easily be spoiled in the process; I always cover them with tissue.

On the prototype of *Turquoise* with all-sheet wings Trevor Faulkner used 30–70% dope-thinner and writes: "With as much castor oil as will dry without stickiness; if the mix dries fast I add more oil for the next coat. Beauty of thin dope is that one has time for adjustment before the finish is complete. After light sanding there is a slight lustre on the wings."

One of the best ways is to use much diluted (25–75%) dope-thinner mixture (adding *one* drop C.O. per 10 c.c.) for stretching only, on some material that already has a grain to it, and keep wing in jig till dry. Three coats are more than enough. Modelling tissue is a good answer, it is strong and the two sides are different, one silky and shiny the other less so. The very thin ("Jap") tissue is excellent when treated with respect.

Common modelling tissues come in a surprising variety of different surface textures. The rough side of some of the thicker tissues give a finish that is an approximation to a bird wing's upper surface. For the underside choose a finer and silkier tissue.

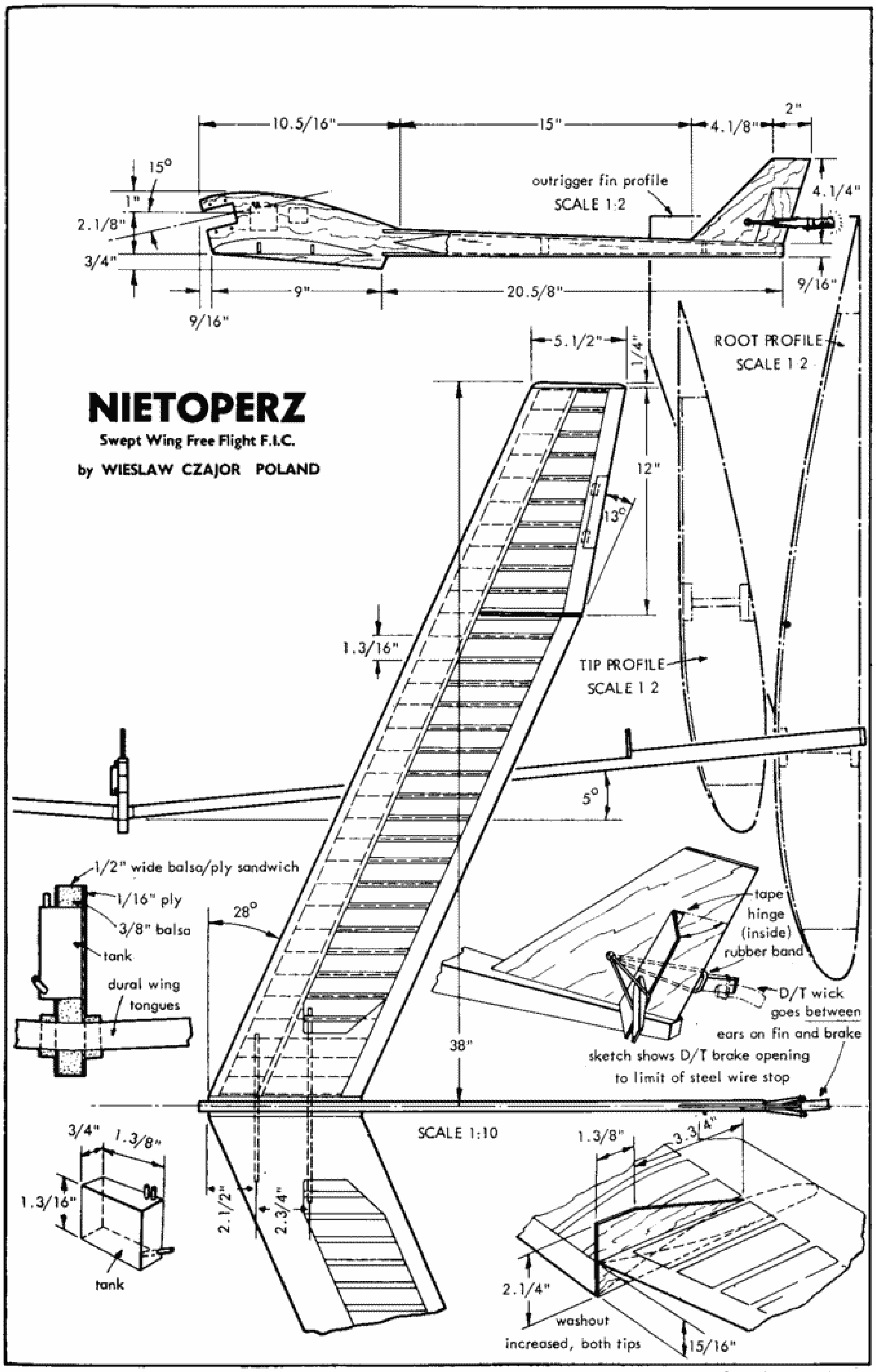
Something to think about? We hope this little dissertation will provide some basis for more discussion, and perhaps a little better understanding of how and why glider airfoils work.

TABLE 7

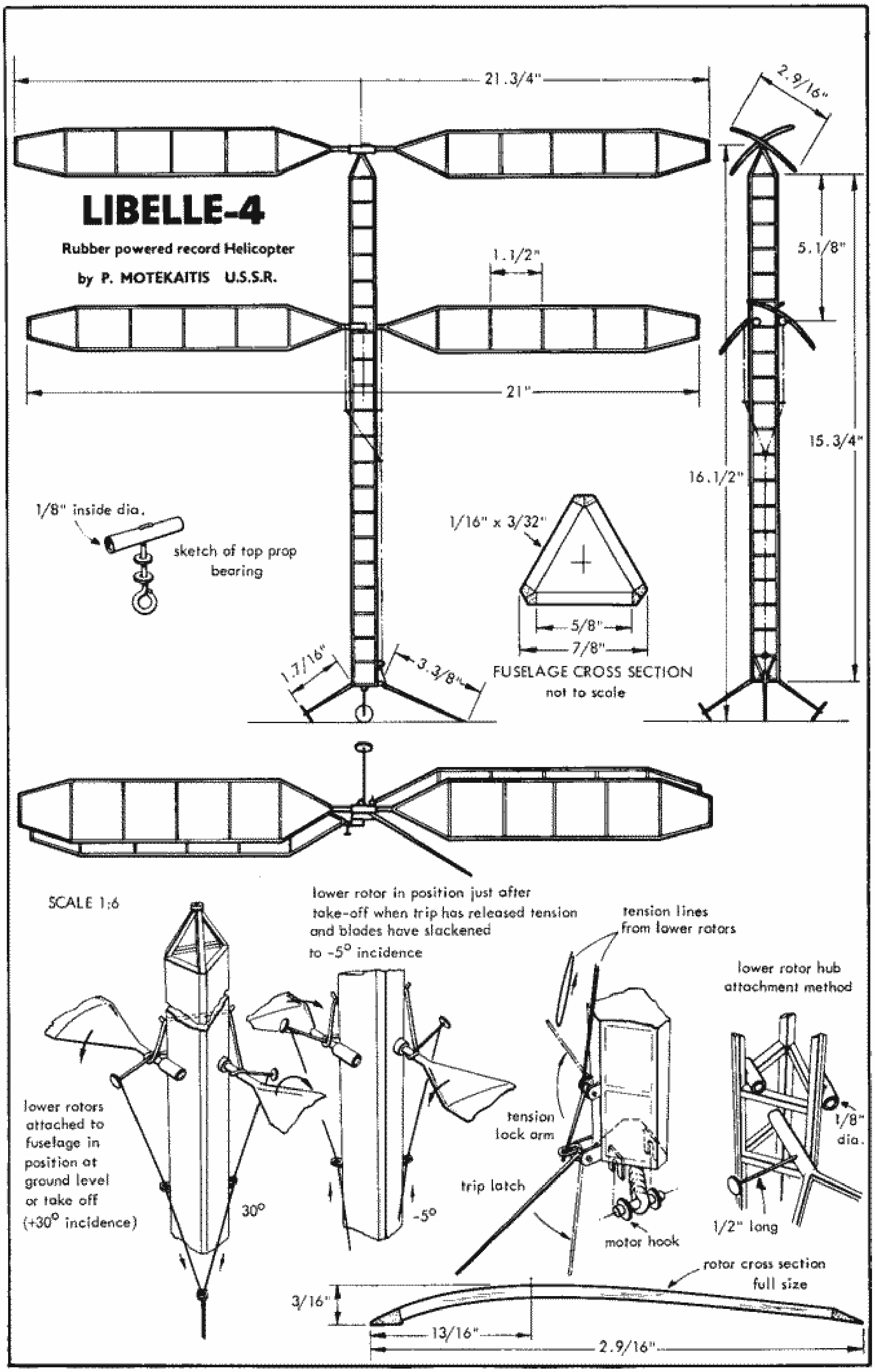
		0	1·25	2·5	5	7·5	10	15	20	25	30	40	50	60	70	80	90	100	
Wortmann 62-K	sk	0	—	0·4	1	1·3	1·65	2·25	2·65	3	3·2	3·45	3·5	3·43	3·2	2·75	1·83	0	a
	sk	0	—	0·6	1·5	1·95	2·5	3·37	3·97	4·5	4·8	5·17	5·25	5·15	4·77	4·1	2·75	0	a × 1·5
	r	0	—	—	2·75	3·7	4·25	5·2	5·75	6·2	6·5	6·75	6·45	5·75	4·25	2·8	1·15	0	
Eppler 387	sk	0	—	0·5	1·15	1·4	1·75	2·35	2·9	3·2	3·5	3·75	3·5	3·05	2·5	1·72	1	0	
	r	0	—	1·6	2·3	2·8	3·25	3·75	4·15	4·3	4·5	4·38	3·8	3	2·28	1·4	0·6	0	
EK-W517		0	—	2	3·2	4·1	4·8	6·2	7·15	7·8	8·25	8·5	8·3	7·9	7	5·7	3·15	0	
		0	—	0·5	0·2	0·05	0·2	0·45	0·75	1·15	1·4	1·75	2·2	2·5	2·7	2·5	1·8	0	
EK-16E8		0·5	3·3	4·5	6·3	7·5	8·4	9·5	9·95	10·2	10·1	9·3	8·3	7·05	5·65	4·1	2·15	0	
		0·5	2·25	0·2	0·1	0·35	0·65	1·35	2·05	2·75	3·3	3·75	3·9	3·4	2·7	1·8	0·85	0	
EK-W519		0	—	2·45	3·8	4·9	5·8	7·2	8·7	9·05	9·4	9·75	9·5	8.9	7·75	6·25	3.9	0	
		0	—	0·85	0.75	0·7	0·6	0·4	0·2	0	0·2	0·6	1.0	1·4	1·8	2.0	1·6	0	

Bibliography and Notes

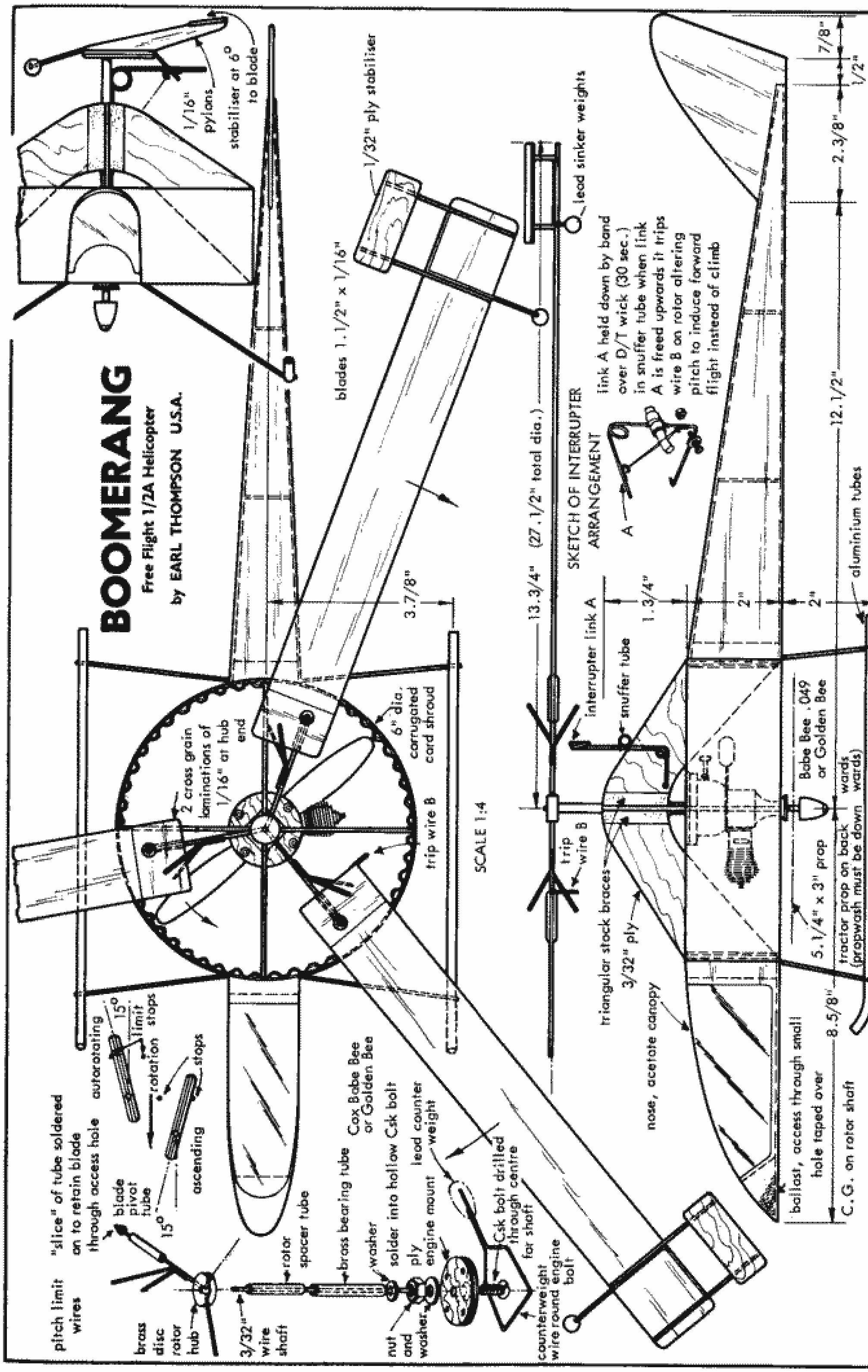
1. T. J. W. van Lammeren, *Aircraft Performance*, Stam, Holland, 1941.
2. L. Prandtl, *The Essentials of Fluid Dynamics*, Blackie & Son Ltd., 1963, page 140; three photographs show Laminar separation and turbulent reattachment taken at $Re = 2 \times 10^4$, 5×10^4 and 6×10^4 respectively.
3. *AMA* 73/74, pages 26 and 27.
4. A fighter with chord 2 metres flying at the speed of sound flies at $Re = 70 \times 332 \times 2000 = 46{,}480{,}000$; a glider with chord 60 cm. flying at 108 km/h flies at $Re = 70 \times 30 \times 600 = 1{,}260{,}000$.
5. "The sum of pressure and the half product of density and the square of speed is constant."
6. O. Lilienthal, *Der Vogelflug als Grundlage der Fliegekunst*, 3rd ed. p. 76 (Munich 1938).
7. Those interested might read G. W. Lewis in *Journal of the Royal Aeronautical Society*, May 1939 (27th Wilbur Wright Memorial Lecture).
8. Theodorsen, in *Report of NACA*, Washington, No. 411 (1931); also Theodorsen & Garrick, ibid., No. 452 (1933).
9. A. Betz, in *Luftfahrtforschung*, Vol. II, no. 6 (1934).
10. Dissertations are listed in Prandtl (note 2) p. 113.
11. For a faulty and confusing explanation see *AMA* 70/71, p. 63.
12. See Beuermann's method in *AMA* 61/62.
13. F. W. Schmitz, *Aerodynamik das Flugmodells*, Vol. I, Tragflugel-messungen; Berlin 1942.
14. F. W. Schmitz, *Aerodynamik das Flugmodells*, Carl Lange Verlag, Duisburg 1957.
15. The designs are by Juste van Hattum.
16. Pfister and Porger, *Grundlagen der Fluglehre*, Vol. V, part 2, p. 35.
17. Joukowski, *Aerodynamique*, Paris 1916
    Karman & Trefftz, in *Zeitschrift fur Flug und Motor*, Vol. 6, p. 173 (1915).
    Karman & Trefftz, ibid., Vol. 9. p. 111 (1918).
    Fuchs, *Aerodynamik*, Vol. 2, 2nd ed.
18. Note that minimum sink has also improved in the last 35 years, but not nearly so spectacularly as the L/D ratio (1935 Moazagotl 58 cm./sec., 1937 Reiher 50 cm./sec.; 1957 Phoenix 48 cm./sec.; 1969 SB-9 45 cm./sec.).



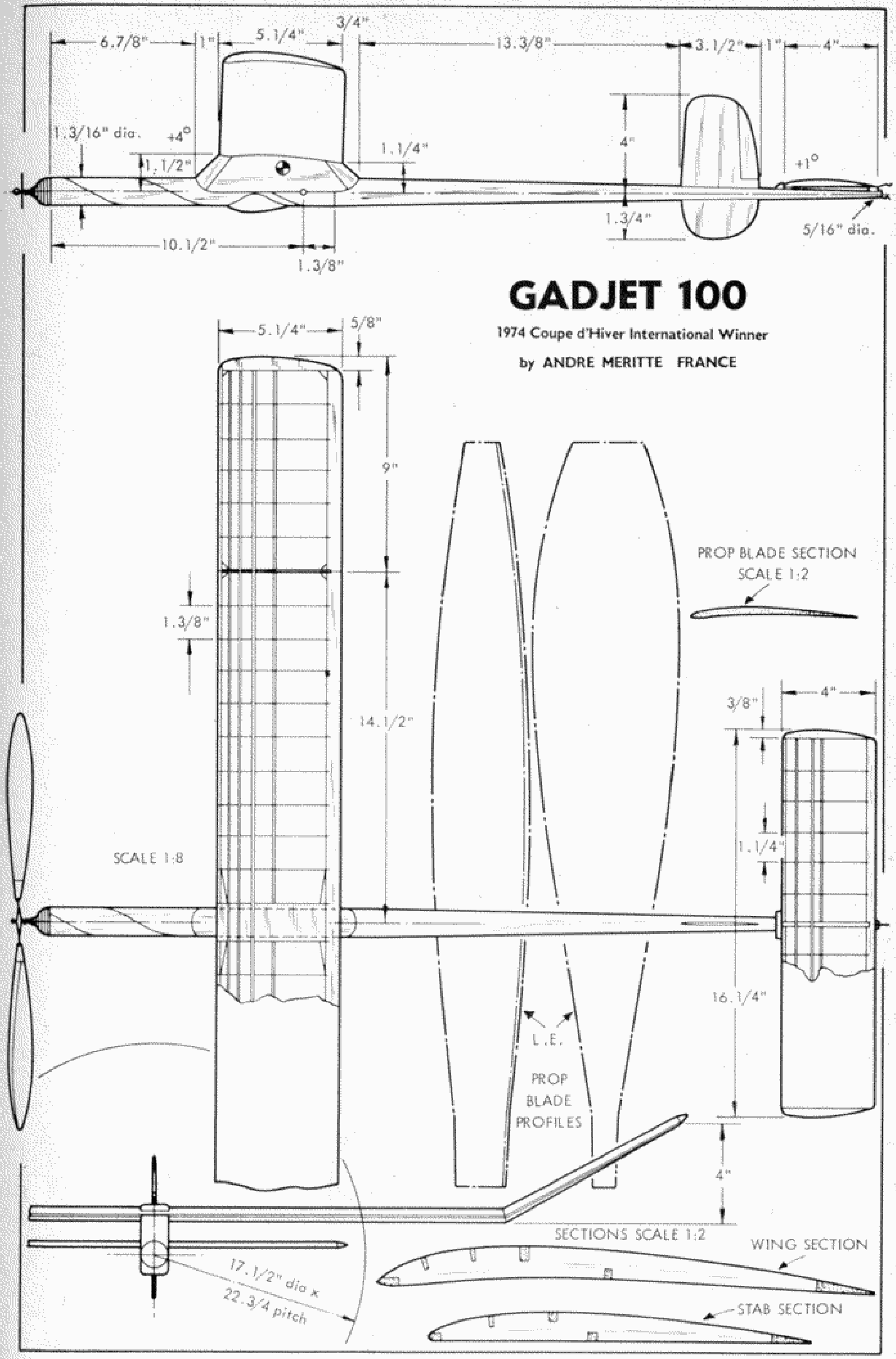
MODELARZ POLAND



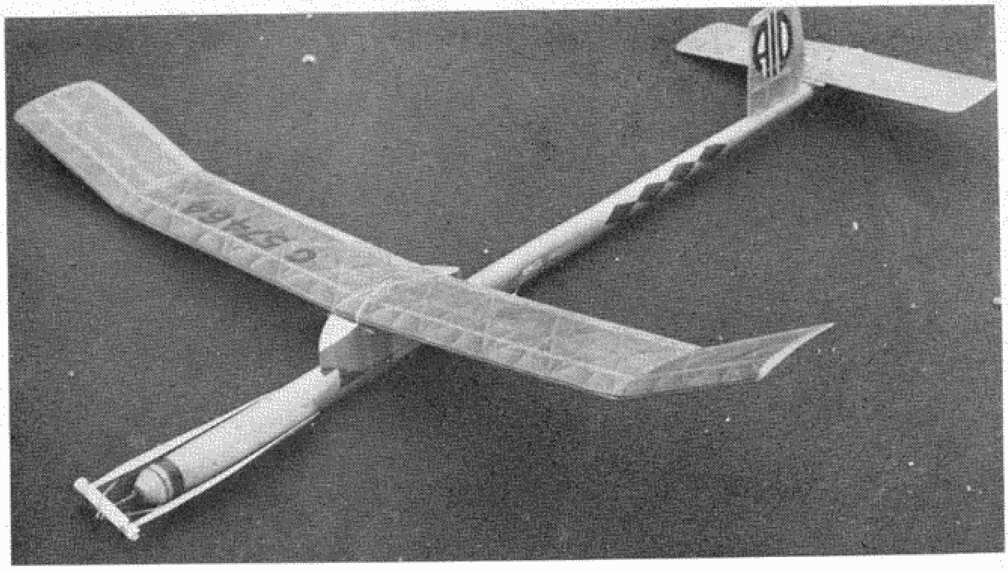
SKRYDLATA POLSKA POLAND



AMERICAN AIRCRAFT MODELER U.S.A.



MODELE REDUIT D'AVION FRANCE



VIT, VIW, or . . . "JUST PLAIN MODEL"
. . . whither the Coupe?
by Ron Coleman

EARLY in 1972 the variable incidence wing was thought to be a possible "answer" to the "Coupe d'Hiver Problem". The best part of a week's half-term holiday was spent in developing and installing the "sliding door" mechanism shown in *Fig*. 1. The whole apparatus worked very smoothly, and my son Piers and I went eagerly to our flying field high on Cleeve Common to carry out the test flights. It was raining (of course!). We had flights of about a minute, and, allowing for the rain, we thought, given luck, we might have a worthwhile model. At the weekend the model was at the Coupe contest in Paris, and we had no luck! The times were uncompetitive. The mechanics were good, but having put all our eggs in one basket with no time for practice or "further development" there was no chance.

Firstly, the sliding rear motor peg should have moved much sooner than it was capable of doing, within, say, ten seconds, instead of after the middle of the motor run when the flight had flattened out, holding the reduced incidence angle too long. Secondly the wing loading was too low, as was the airscrew pitch, to give the desired climb.

Frank Parmenter (U.S.A.) kindly showed me his Wakefield during the 1973 World Championships at Wiener Neustadt. This has a superbly engineered VIW worked from the motor torque acting on the rear motor peg. This operates within the desired time and in *Fig*. 2 I have put his motor peg together with my "sliding door" as a suggested reliable mechanism for Coupe d'Hiver models.

Of course, to do all this work, one has to believe, almost passionately, that a variable incidence wing, or even a VIT is really necessary on a Coupe d'Hiver model. Or a Wakefield, for that matter? The Japanese Mitsuo Kobori came third in the World Championships with what his team manager described to me as a "just plain model, no gadgets!" That is, no VIT, only a fuse-operated dethermalizer to control the flight length.

One has to be convinced that a superior climb can be obtained than is

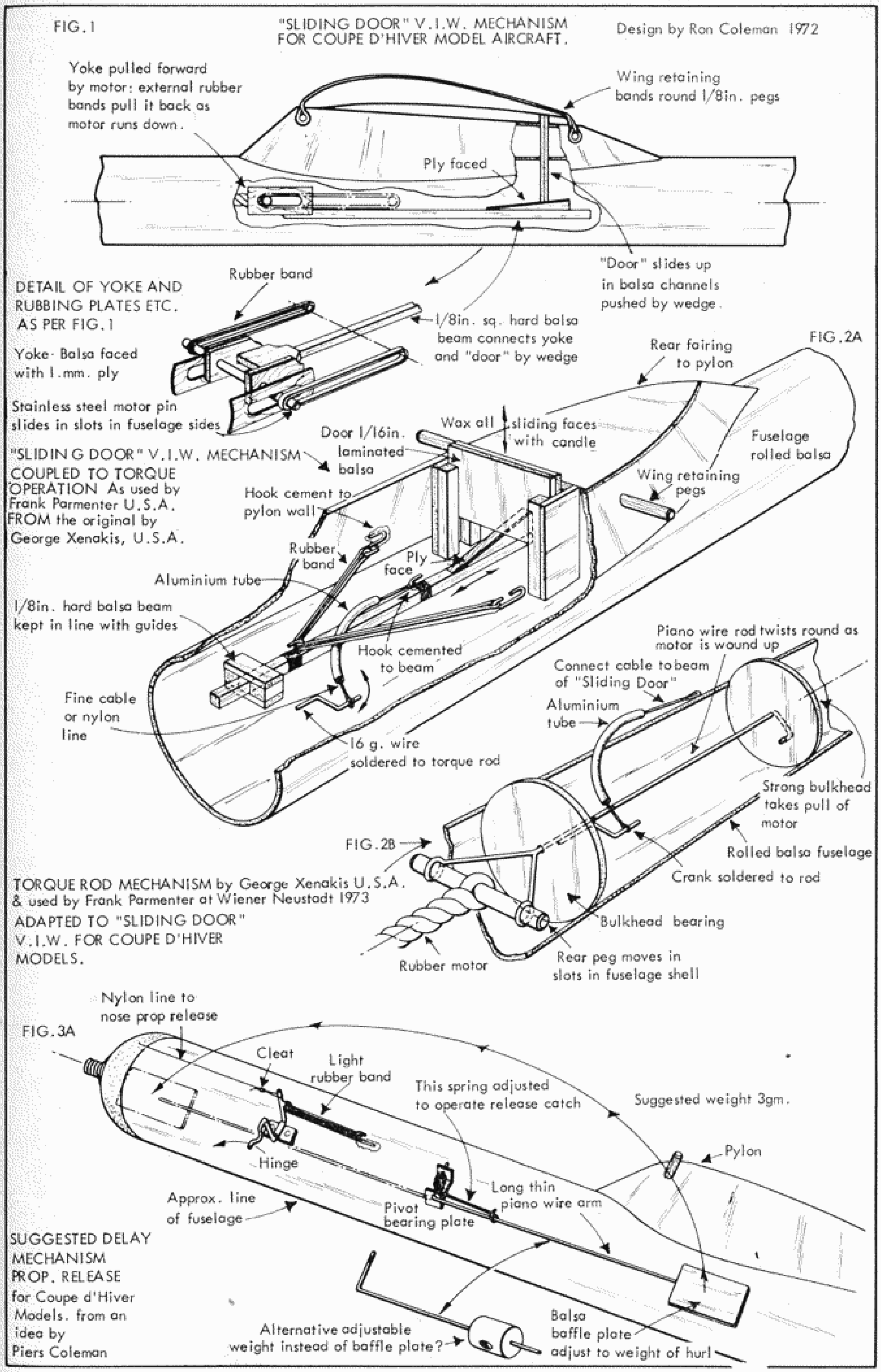
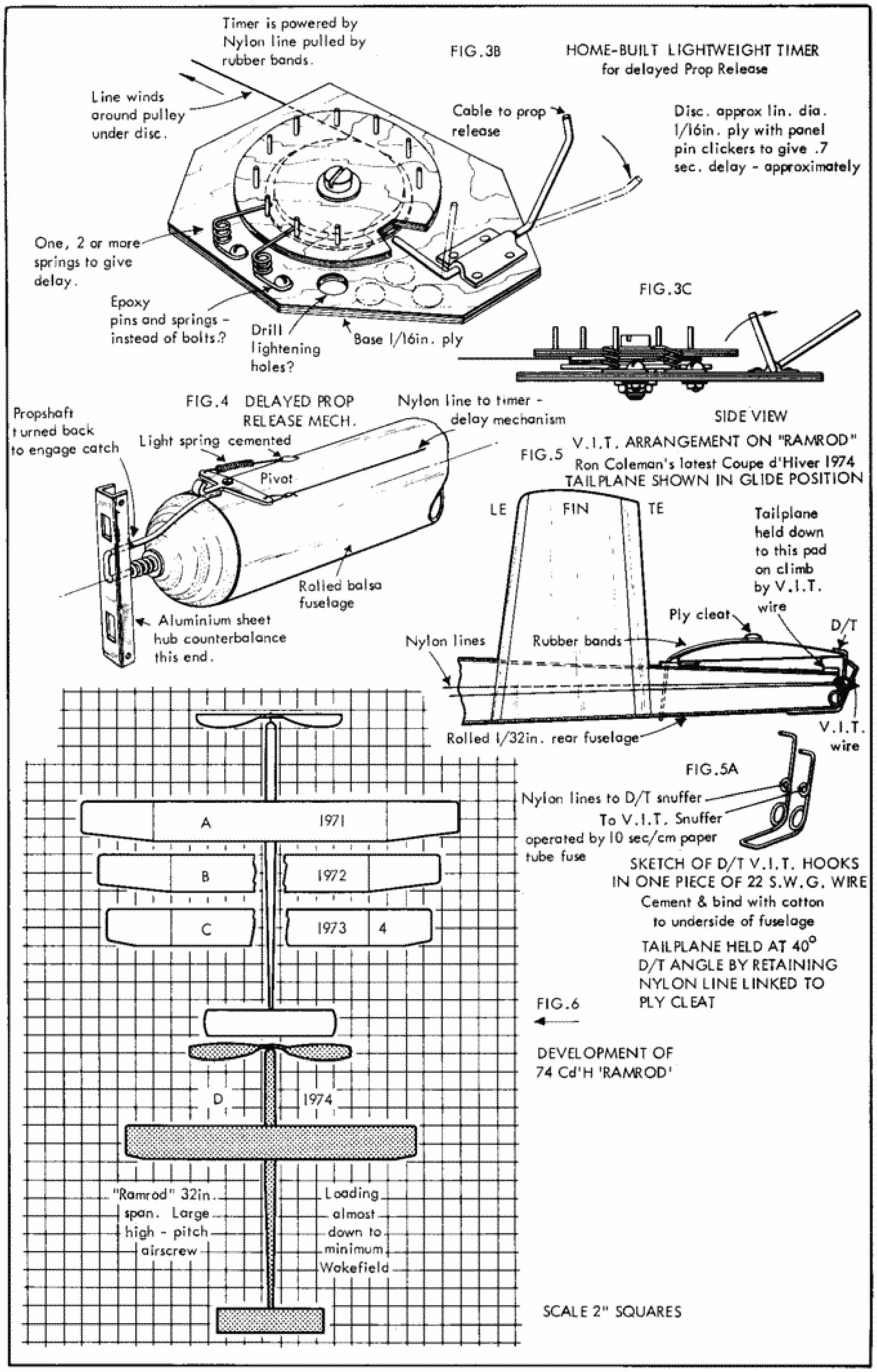


FIG. 1
"SLIDING DOOR" V.I.W. MECHANISM FOR COUPE D'HIVER MODEL AIRCRAFT.
Design by Ron Coleman 1972
Yoke pulled forward by motor: external rubber bands pull it back as motor runs down.
Wing retaining bands round 1/8in. pegs
Ply faced
"Door" slides up in balsa channels pushed by wedge.
Rubber band
DETAIL OF YOKE AND RUBBING PLATES ETC. AS PER FIG. 1
1/8in. sq. hard balsa beam connects yoke and "door" by wedge
Yoke- Balsa faced with 1.mm. ply
Stainless steel motor pin slides in slots in fuselage sides
Rear fairing to pylon
FIG. 2A
Door 1/16in. laminated balsa
Wax all sliding faces with candle
Fuselage rolled balsa
"SLIDING DOOR" V.I.W. MECHANISM COUPLED TO TORQUE OPERATION As used by Frank Parmenter U.S.A. FROM the original by George Xenakis, U.S.A.
Hook cement to pylon wall
Wing retaining pegs
Rubber band
Ply face
Aluminium tube
1/8in. hard balsa beam kept in line with guides
Hook cemented to beam
Piano wire rod twists round as motor is wound up
Connect cable to beam of "Sliding Door"
Fine cable or nylon line
Aluminium tube
16 g. wire soldered to torque rod
Strong bulkhead takes pull of motor
Rolled balsa fuselage
FIG. 2B
Crank soldered to rod
TORQUE ROD MECHANISM by George Xenakis U.S.A. & used by Frank Parmenter at Wiener Neustadt 1973
ADAPTED TO "SLIDING DOOR" V.I.W. FOR COUPE D'HIVER MODELS.
Bulkhead bearing
Rubber motor
Rear peg moves in slots in fuselage shell
Nylon line to nose prop release
FIG. 3A
Cleat
Light rubber band
This spring adjusted to operate release catch
Suggested weight 3gm.
Pylon
Hinge
Long thin piano wire arm
Approx. line of fuselage
Pivot bearing plate
SUGGESTED DELAY MECHANISM PROP. RELEASE for Coupe d'Hiver Models. from an idea by Piers Coleman
Balsa baffle plate adjust to weight of hurl
Alternative adjustable weight instead of baffle plate?



Timer is powered by Nylon line pulled by rubber bands.
FIG.3B
HOME-BUILT LIGHTWEIGHT TIMER for delayed Prop Release
Line winds around pulley under disc.
Cable to prop release
Disc. approx 1in. dia. 1/16in. ply with panel pin clickers to give .7 sec. delay - approximately
One, 2 or more springs to give delay.
Epoxy pins and springs - instead of bolts?
Drill lightening holes?
Base 1/16in. ply
FIG.3C
SIDE VIEW
FIG.4 DELAYED PROP RELEASE MECH.
Nylon line to timer - delay mechanism
Propshaft turned back to engage catch
Light spring cemented
Pivot
Rolled balsa fuselage
Aluminium sheet hub counterbalance this end.
FIG.5
V.I.T. ARRANGEMENT ON "RAMROD"
Ron Coleman's latest Coupe d'Hiver 1974
TAILPLANE SHOWN IN GLIDE POSITION
LE
FIN
TE
Tailplane held down to this pad on climb by V.I.T. wire
Ply cleat
D/T
Nylon lines
Rubber bands
Rolled 1/32in. rear fuselage
V.I.T. wire
FIG.5A
Nylon lines to D/T snuffer
To V.I.T. Snuffer operated by 10 sec/cm paper tube fuse
SKETCH OF D/T V.I.T. HOOKS IN ONE PIECE OF 22 S.W.G. WIRE
Cement & bind with cotton to underside of fuselage
TAILPLANE HELD AT 40° D/T ANGLE BY RETAINING NYLON LINE LINKED TO PLY CLEAT
A 1971
B 1972
C 1973 4
D 1974
FIG.6
DEVELOPMENT OF 74 Cd'H 'RAMROD'
"Ramrod" 32in. span. Large high - pitch airscrew
Loading almost down to minimum Wakefield
SCALE 2" SQUARES

possible with the "plain model" when using VIT, VIW or, delayed-action release prop as used by Mike Thomas of Canada and John O'Donnell.

My recent experiments seem to confirm this. This year I tried (again!) for the climb, believing that if you don't get your Coupe into a thermal it will not max anyway, and thermals (in England!) do not seem to develop very close to the ground. First, eight strands in a 36-in. span six-strand model, with a 24-in. pitch (up 4 in.) prop. I started "slamming" the model up at a much higher angle, and with extra right thrust the climb began to show promise. The model then took first place at the ST. ALBANS Spring Gala Coupe d'Hiver contest. The idea of getting the extra 20 feet or so altitude from delayed action prop release as propagated by O'Donnell and others I believe to be very worthwhile, if you don't mind the extra weight of a clockwork timer to give the necessary three-quarters of a second or thereabouts delay. Perhaps much lighter mechanisms could be devised and two ideas which I have thought of trying are sketched in *Fig.* 3 and in *Fig.* 4 is a suitable prop release. The weight of the timer is a problem as far as I am concerned as I don't build light models easily, and anyway my models have to be strong in the wing to stand the rough treatment up on my high windy Cleeve Common.

The next thing was to drop the wing span still further, reasoning that if a Wakefield can max out so well at its wing loading, then why not a Coupe at a similar, though not quite so high a loading. The latest wing using Benedek 7406F section at $3\frac{3}{4}$-in. chord is down to 32-in. span which is still about 20 square inches area above the lowest possible to equal a Wakefield loading.

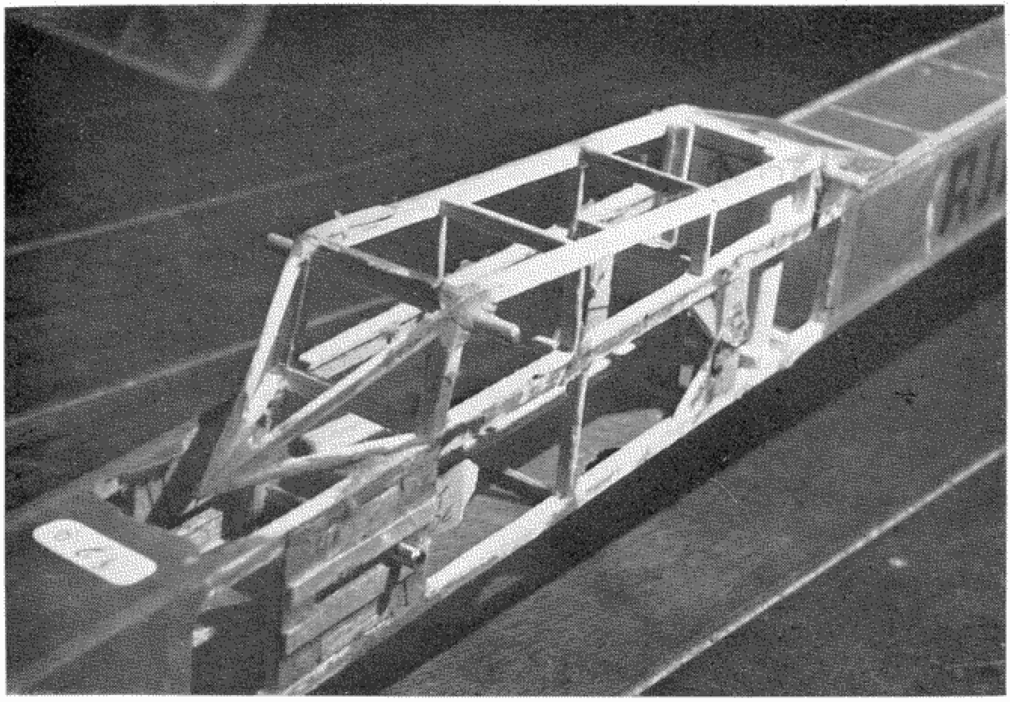
At the same time, a variable incidence tailplane, *Fig.* 5 was added, using a rapid burning fuse (10 secs/centimetre) to operate it. The model, I have called *Ramrod* after the way it takes a high angle launch with as much push as I can muster!

The launch sequence goes like this:

1. Anticipating thermal, wind up to max turns (about 210) on eight strands.
2. Wait for thermal, using bubble machine, thermistor, or your own good thermal "nose"!
3. On decision to launch, light main DT fuse from fuse "bomb"
4. Check that prop blades are in "out" position, light fast VIT fuse from "bomb".
5. Drop fuse "bomb" on ground—it will extinguish itself in its snuffer tube. Watch fast fuse burn through one centimetre.
6. You now have five seconds. As the burn passes five seconds before the rubber band, the launch is made with as much force as possible, slightly right of the wind.

The model should wing over at the top of its first stage of fast climb just before the VIT operates. to continue on up in the secondary climb, with a motor run of 25 to 30 seconds. *Ramrod* will fly at the same wing and tail settings as a good non-VIT model providing that the launch is neither as steep nor as vigorous; otherwise it will stall, and possibly power dive! It attains a good height —it is necessary to launch right of the wind slightly—but the VIT version goes some 20 to 30 feet higher. Given that the model is launched into a thermal, there seems very little in it, excepting that the VIT model could be expected to be more likely to find any weak thermal which developed that little bit higher up.

It might be well to take a look at the main divisions of Coupe d'Hiver models with regard to wing spans and whether six or eight strand motors. We will categorize them A, B, C, and D. See *Fig.* 6.



Model A. 40 to 42 inches wing span (or more) "French Style" Chord 4 in. to $4\frac{1}{2}$ in. Mostly slab side fuselage and eight strands needed to get any sort of altitude. Good performance in good (French!) conditions but not suitable for typical rough English weather. Glide can be superb.

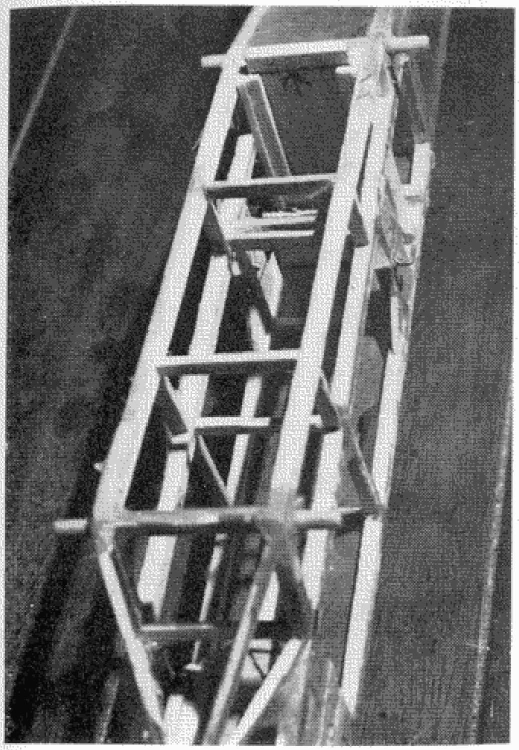
Model B. French and English style 36 to 38-in. span. Chord around 4 in. Majority of models built fall into this group. Mostly slab side fuselages, but some circular. Majority of models have six strands. Baron Knight a well-known example. Climb long and slow, in comparison with:—

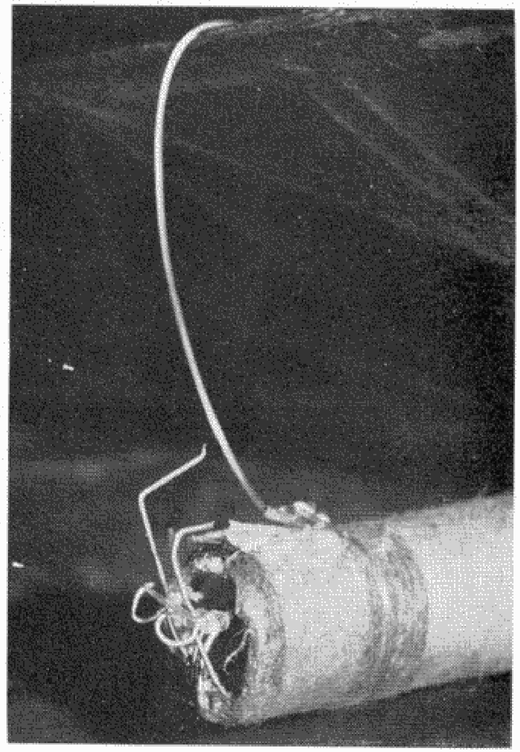
Model C. 36-in. span, 4-in. chord. Eight strands with larger pitch prop, 24 in. Circular rolled balsa fuselage, Schwartzbach 68 section with thread turbulator. Fully streamlined pylon. With right thrust on prop, model can be hurl launched. Climb can be spectacular.

Model D. 32 in. span, $3\frac{3}{4}$-in. chord. 8 strands, larger pitch prop 26 in., diameter 18 in. Uses VIT, or can be "just plain model". Fast flying model with very good climb. Almost down to Wakefield wing loading. Benedek 7406F section, turbulated.

Model C, 36-in. span, 4-in. chord with sections turbulated, is approaching the best that can be obtained from only 10 grammes of rubber, for a gadget-free model.

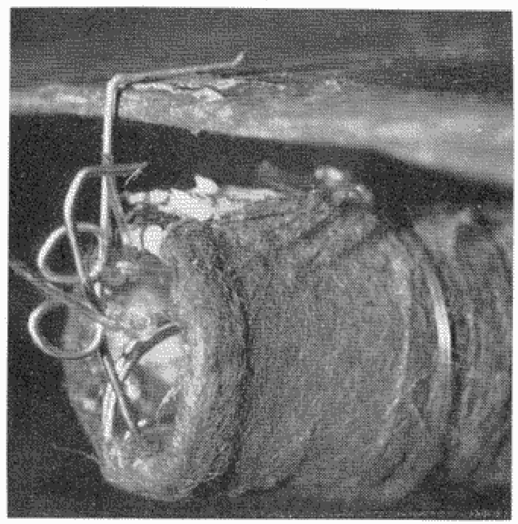
Model D. This seeks height where the thermal is. With VIT, or VIW, it could also use delayed-action prop release, and auto rudder, but the pre-flight servicing and discipline required to cope with all the gadgetry in an important contest are considerable factors to take into account.





Part stripped fuselage of VIW in Harlequin Coupe series. "Sliding Door" at rear of pylon can be seen in the "UP" position, when wing is at reduced incidence for launch. In view opposite the "Sliding door" in "DOWN" position, wing at gliding angle. Note motor peg at rear of slot.

Above right: "Ramrod" showing tailplane in DT position with retaining nylon line. Note 22 g piano wire fitting.



Tail end of "Ramrod" showing 22 g piano wire fitting holding tail in glide position. Rolled $\frac{1}{32}$ in. sheet balsa fuselage reinforced with rings of cotton cemented, plus cotton binding to hold wire fittings in place. All cemented.

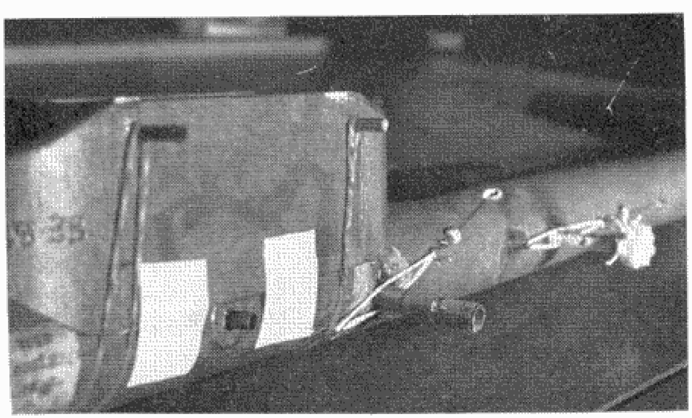
My own scheme for the coming year is to use *Ramrod* with VIT on windy days when thermals are starting higher up, and without VIT when the thermals are clear on sunny, windy days and when I cannot summon up the energy required to cope with the intricacies plus the hard launch.

But on sunny, thermal, non-windy days, 36-in. span, 4-in. chord turbulated Schwartzbach 68, eight strand, 24-in. pitch, 18-in. diameter prop, rolled fuselage, all geodetic, for me, is the best there is . . . "look, just plain model—no gadgets!" Oh, chuck it, Ron!

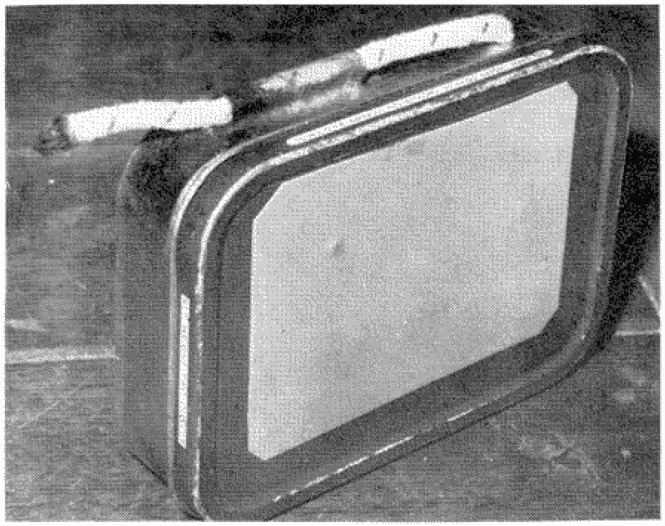
HOW TO MAKE FAST BURNING VIT FUSE

by Ron Coleman

1. Mix two level teaspoons of potassium nitrate (saltpetre) in 5 oz. hot water. A photographic measure is handy for this.
2. Cut newspaper into strips exactly $7\frac{1}{2}$ centimetres wide.
3. Mark off edge of strip in centimetre divisions with red ballpoint pen.
4. Soak newspaper strips in the saltpetre solution for 10 minutes. Put outdoors in sunshine to dry thoroughly.
5. Cut strips of prepared paper into suitable short lengths (about 200 mm.) and roll tightly onto a waxed $\frac{3}{16}$ in. diameter dowel rod.
6. Paste down edge for $\frac{1}{8}$ in., wrap with strip rubber for 2 minutes and twist and slide off dowel rod. Allow to dry for 24 hours, and cut into 3 or 4 cm. lengths. "Gloy" paste is very suitable.



Fuselage of "Ramrod". Note: a) Pylon adjustable for variable CG on round balsa tube. Held by 2 square pieces adhesive masking tape each side plus 2 rubber bands. b) VIT fast burn fuse. c) DT fuse. VIT fuse burning, five seconds before band, 10 secs before band breaks and VIT operates.

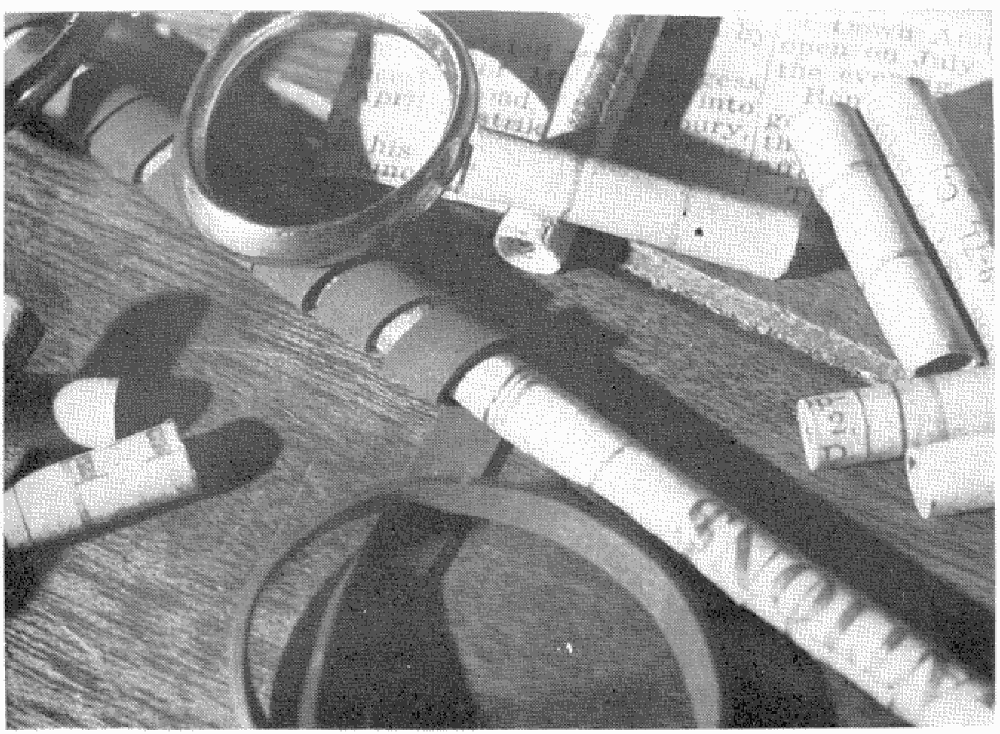


Fuse "Bomb" to light DT fuses, VIT fuse etc. made from tobacco tin with tinplate tube soldered on to snuff out fuse to prevent wastage. Bright red fluorescent panel on lid enables it to be seen among grass. Box also used as fuse storage tin besides odd drills, pins, cutter blades and similar small accessories.

The fuse fits into a dethermalizer type aluminium tube in the model's fuselage, having an internal diameter of $\frac{5}{16}$ in.

Fuse burns at rate of 10 seconds per centimetre. A stronger or weaker saltpetre solution speeds up or slows down the rate of burning. Check speed of burning with stop watch over a large number of samples in order to establish a known rate of burning.

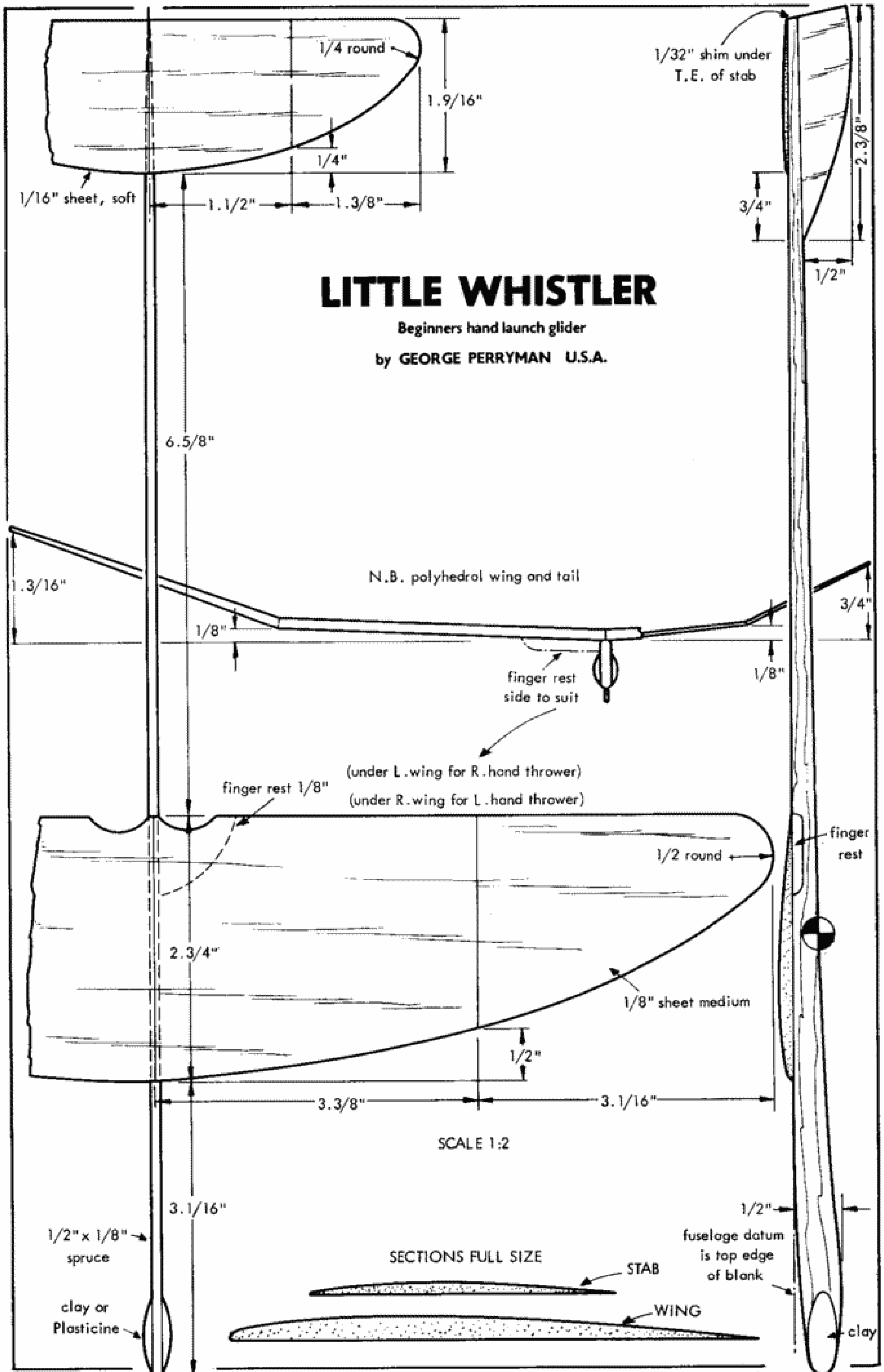
3 cm cut lengths of VIT fuse, and dowel rod with fuse paper rolled on, rubber strip wound on to pull edge down and seal pasted edge.



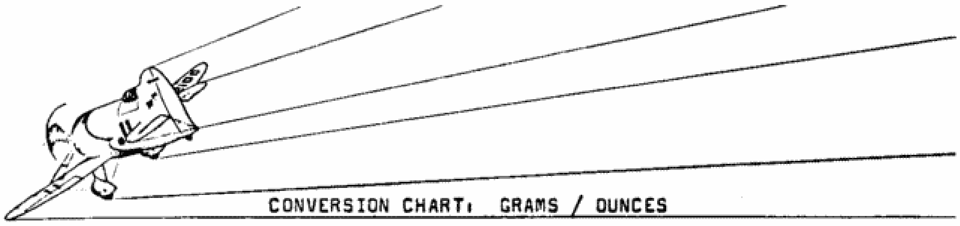
LITTLE WHISTLER

Beginners hand launch glider

by GEORGE PERRYMAN U.S.A.



STAR SKIPPERS NEWS LETTER U.S.A.



CONVERSION CHART: GRAMS / OUNCES

From- VERN CLEMENTS P.O. Box 608 Caldwell, Idaho Zip 83605

GRAMS	=	OZ.	GRAMS	=	OZ.	GRAMS	=	OZ.	GRAMS	=	OZ.
2.835		.10	148.8375		5.25	347.2875		12.25	545.7375		19.25
5.67		.20	155.925		5.5	354.375		12.5	552.825		19.5
7.0875		.25	163.0125		5.75	361.4625		12.75	559.9125		19.75
8.505		.30	170.10	=	6 oz.	368.55	=	13 oz.	567.00	=	20 oz.
11.34		.40	177.1875		6.25	375.6375		13.25	574.0875		20.25
14.175		.50	184.275		6.5	382.725		13.5	581.175		20.5
17.01		.60	191.3625		6.75	389.8125		13.75	588.2625		20.75
19.845		.70	198.45	=	7 oz.	396.9	=	14 oz.	595.35	=	21 oz.
21.2625		.75	205.5375		7.25	403.9875		14.25	623.7	=	22 oz.
22.68		.80	212.625		7.5	411.075		14.5	652.05	=	23 oz.
25.515		.90	219.7125		7.75	418.1625		14.75	680.4	=	24 oz.
28.35	=	1 oz.	226.80	=	8 oz.	425.25	=	15 oz.	708.75	=	25 oz.
35.4375		1.25	233.8875		8.25	432.3375		15.25	737.1	=	26 oz.
42.525		1.5	240.975		8.5	439.425		15.5			
49.6125		1.75	248.0625		8.75	446.5125		15.75			
56.70	=	2 oz.	255.15	=	9 oz.	453.60	=	16 oz.			
63.7875		2.25	262.2375		9.25	460.6875		16.25			
70.875		2.5	269.325		9.5	467.775		16.5			
77.9625		2.75	276.4125		9.75	474.8625		16.75			
85.05	=	3 oz.	283.50	=	10 oz.	481.95	=	17 oz.			
92.1375		3.25	290.5875		10.25	489.0375		17.25			
99.225		3.5	297.675		10.5	496.125		17.5			
106.3125		3.75	304.7625		10.75	503.2125		17.75			
113.40	=	4 oz.	311.85	=	11 oz.	510.30	=	18 oz.			
120.4875		4.25	318.9375		11.25	517.3875		18.25			
127.575		4.5	326.025		11.5	524.475		18.5			
134.6625		4.75	333.1125		11.75	531.5625		18.75			
141.75	=	5 oz.	340.2	=	12 oz.	538.65	=	19 oz.			

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12900 Fox 29	5·0 c.c.	22900 Fox 29RC	5·0 c.c.
13500 Fox 35	5·9 c.c.	23600 Fox 36RC	6·0 c.c.
13600 Fox 36	6·0 c.c.	26099 Fox 60RC	10·0 c.c.
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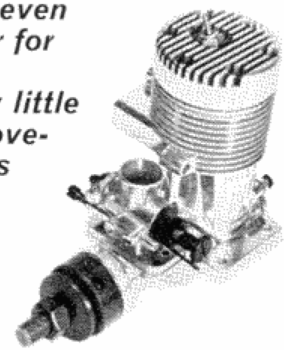

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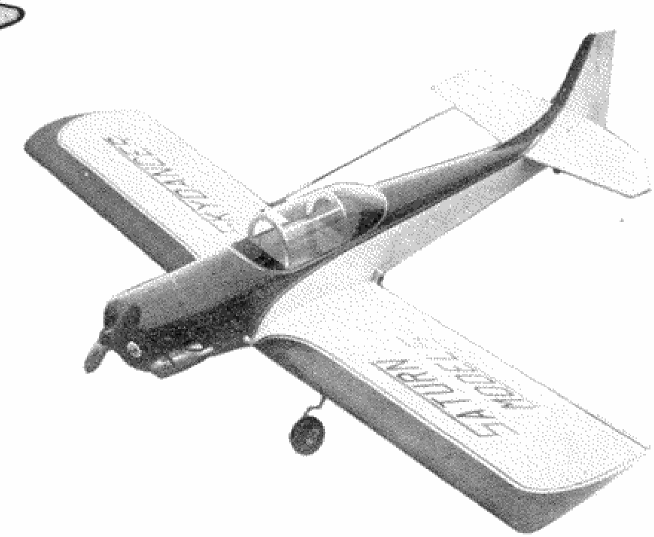
SATURN MODELS



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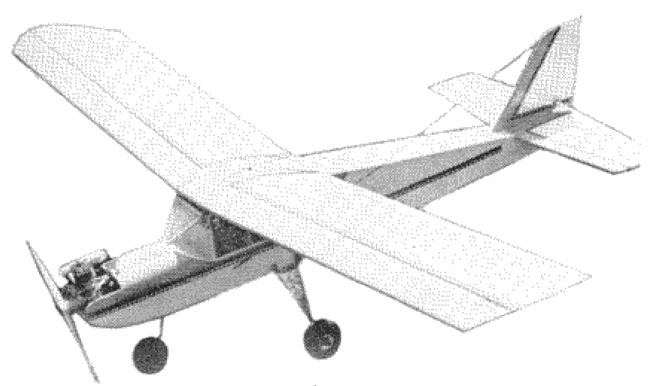

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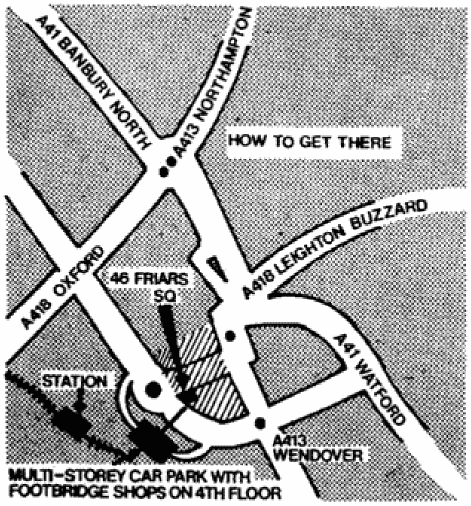
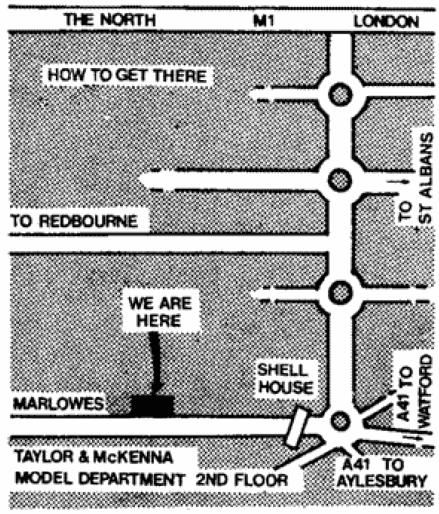
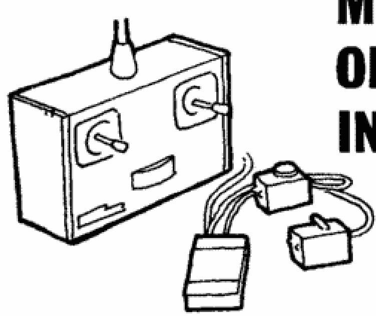
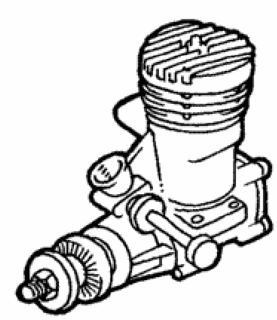


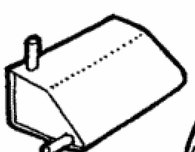


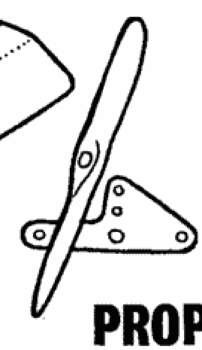


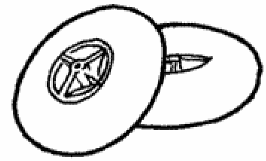
MOST LEADING MAKES OF KITS IN STOCK

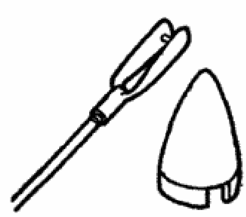


BEGINNER OR ENTHUSIAST









PROPS SPINNERS, ETC.

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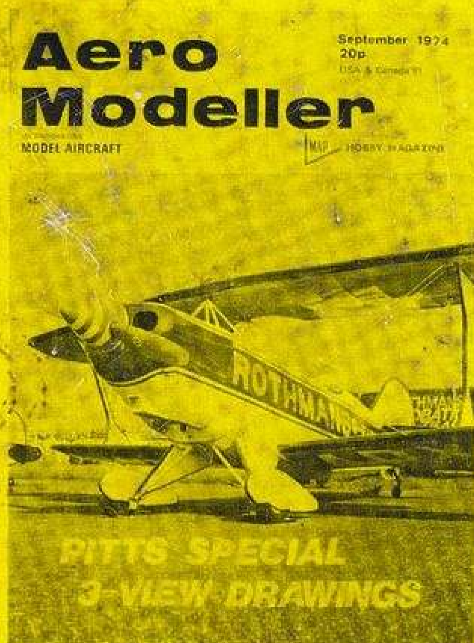

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