Aero Modeller

Annual 1972-73

PRICE: £1

AERO MODELLER ANNUAL 1972-73

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A review of the year's aero-
modelling 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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Published by
MODEL & ALLIED PUBLICATIONS LTD.
13/35 BRIDGE STREET
HEMEL HEMPSTEAD : HERTS
1972

AEROMODELLER ANNUAL 1972–73

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Trade Distributors
MODEL AND ALLIED PUBLICATIONS LTD.
FOUNTAIN PRESS
STATION ROAD
KINGS LANGLEY
HERTS., U.K.

Printed in Great Britain by
STAPLES PRINTERS LIMITED AT THEIR ROCHESTER, KENT, ESTABLISHMENT

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INTRODUCTION

YEAR by year, this page has chronicled a reflection on achievement trends and changing habits in the world of aeromodelling. Anyone lucky enough (and we really do *mean* lucky enough) to own a whole set of *Annuals* since the first one appeared in 1948 will possess as fine a record as can be found anywhere of aeromodelling progress in technique and design. One can browse for hours in back editions. Discover inventions now forgotten, revise ideas that have gone dormant, note how forecasts have come true and study the ever-changing shapes of models as well as the modern "knock-offs" of much earlier designs.

There have been vintage years filled with a bonus of achievement and there have been negative years which many prefer to forget.

Alas, this past season comes into the latter category in some respects. It has seen a mischievous lobbying within the Society of Model Aeronautical Engineers to cancel progressive efforts to run a World Indoor Champs and International pylon event. It has seen insurance houses raising their rates for third party cover to many times the previous premium. It has seen the organisers of three World Championships hard pressed to find funds in spite of a 50% increase in entry fees and, worst of all, the year 1972 has produced the coldest, wettest, windiest succession of Sundays within memory.

Yet the modellers smile their way through all of this. Fantastic records have toppled old figures. Over 19 hours aloft with a glider; almost 2 hours with an indoor model; 72 minutes with a helicopter, and as for speeds—well, they are so fast that the F.A.I. has to seek ways of rationalising methods of timekeeping to cope.

We have seen new ventures in scale modelling with yet more "impossible" subjects becoming very much possible with the aid of radio control. Pylon racing has risen in popularity to the extent that, like combat in control line, the entry into events has to be restricted or subjected to eliminators in order to cope with the numbers.

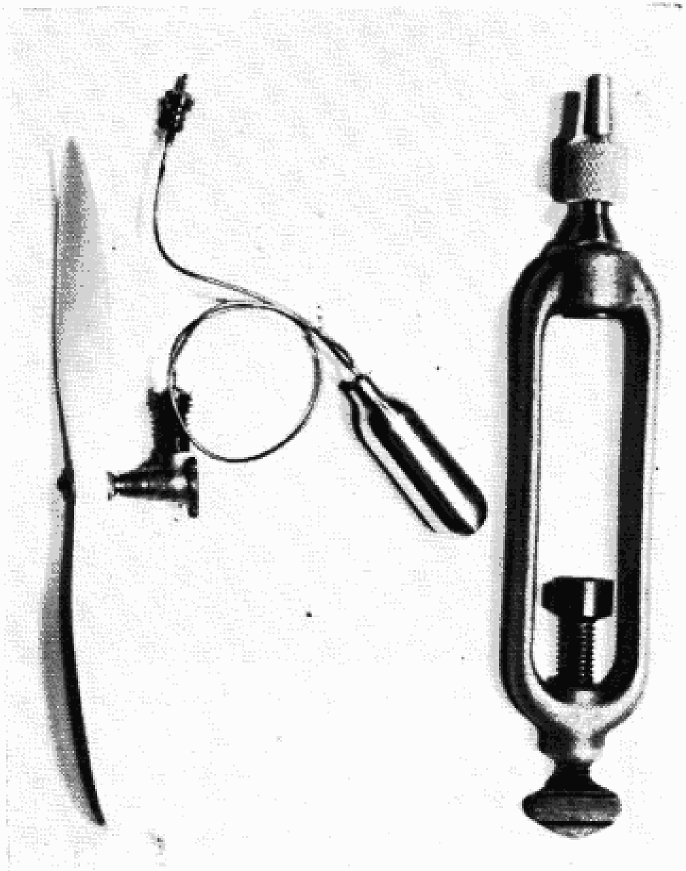
Electric flying, both round the pole in our *Model Engineer* exhibition and outdoors (see feature in this *Annual*), has come within the reach of everyman, and the following for thermal soaring has also gone ahead by leaps and bounds.

This year our theme might well be titled "*The Silent Revolution*" as a summary of our contents. Why not strike out for more silence—more hush will crush the aggressive anti-model-flying militants. We have Doug McHard's masterly treatment of the Brown Junior CO_2 motor as our main feature. These little units, made by Bill Brown in his "retirement" to the Pennsylvania hills, are hard to come by, but we feel they need to be known if only to inspire others to venture into manufacture. Doug evades the cost per flight. We suspect he does so because CO_2 is almost embarrassingly cheap to operate! Then we have a Winkler thesis on F1E, or in other words the International class for magnet steering gliders. In Europe this kind of model has a huge following. British hills cry out for magneteers. 1972 also seemed to be "airfoil" year. Our offices had more enquiries for airfoil data than is customary. This edition should have enough to satisfy the most demanding of airfoil collectors.

Finally, the hard world of commerce has snared us with yet another price increase. Over the past three years, the *Annual* has seen a progressive cover price increase to the extent that this edition has to be sold at almost twice the price of all those *Annuals* from 1948 to 1969. This inescapable increase is a reflection on an aspect that affects all walks of life, and one which we endeavour to temper in this *Annual* with an increase in the number of pages to 144. We hope you'll enjoy every single one of them.

EXPERIMENTS WITH CO_2

by J. D. McHard



The complete Brown CO_2 unit, as produced by Bill Brown of Brown Junior Motors Inc. (P.O. Box 77, Pine Grove Mills, Pa. 16868, U.S.A.) in limited numbers. Older readers will know that Bill Brown was the pioneer of internal combustion engines used in quantity for aeromodelling. Photograph is approximately half size. Cost of the unit is in the region of £10 (depends on international exchange fluctuations).

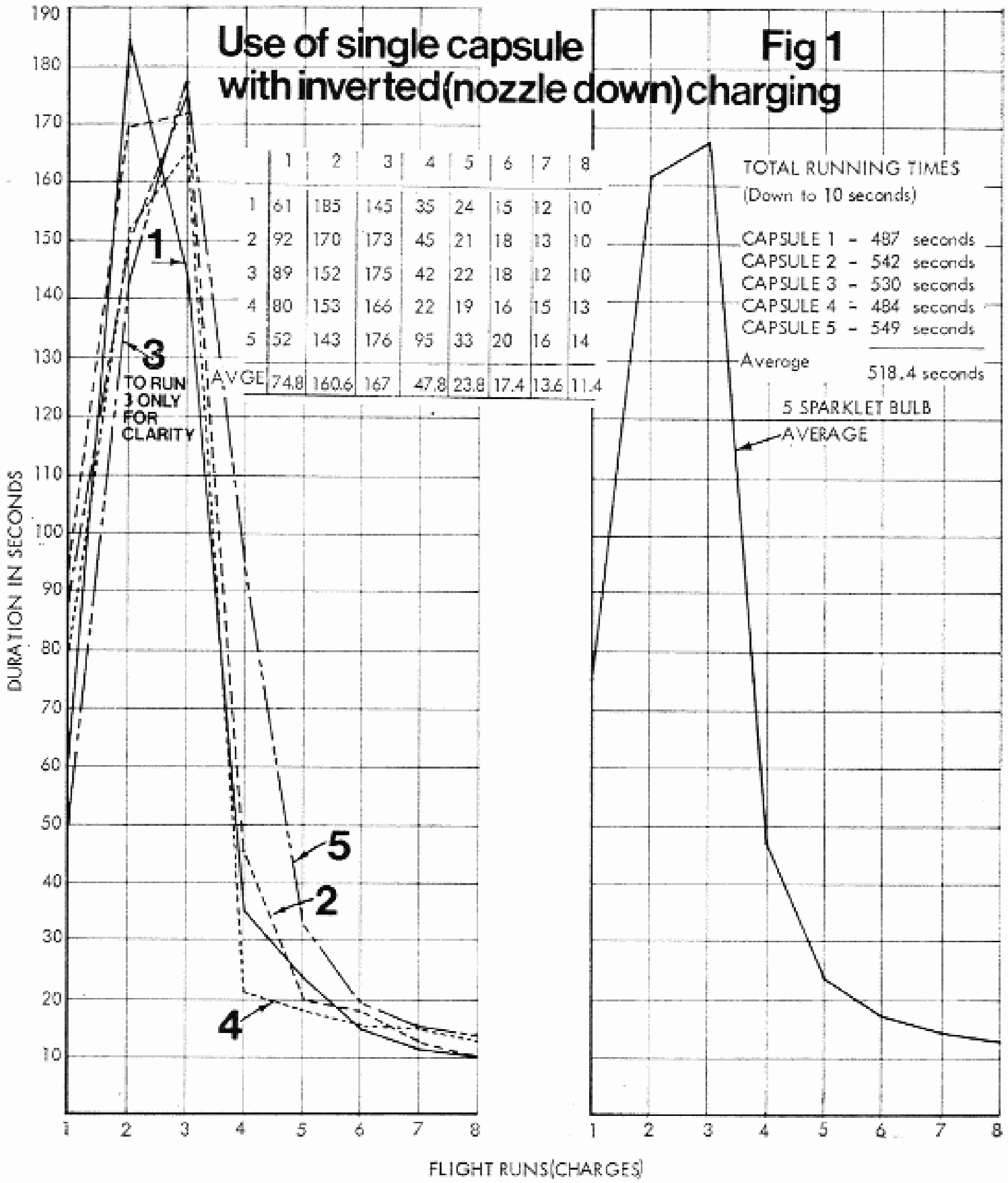
THE CO_2 to drive the engine is stored in a little aluminium flight capsule, which may be recharged several times from a steel Sparklet soda syphon bulb, which is bought from your chemist in boxes of 10.

The process of charging is very similar to that adopted for refilling a gas cigarette lighter (although of course the gas itself is quite different!). It is interesting to study the behaviour of a liquefied gas in certain clear plastic lighter refill cartridges, since it will make the reasons for many of the following phenomena more easily understood.

With this understanding, a good measure of control can be exercised over the number of recharges obtained from each Sparklet bulb and over the duration of the resulting engine runs.

If the flight capsule is charged from a Sparklet bulb held nozzle **down,** liquid CO_2 flows into the small flight capsule; this we will call a *liquid charge*. If, on the other hand, the Sparklet bulb is held nozzle **up** during charging, the flight capsule will receive little or no liquid—only gas, and a much shorter engine run subsequently results. In the following pages we will refer to this as a *gas charge*.

Gas connections between flight capsule and engine should be arranged so that no liquid CO_2 reaches the engine. The flight capsule connection must therefore be arranged from the highest point, although the engine may be mounted in any position relative to the capsule.

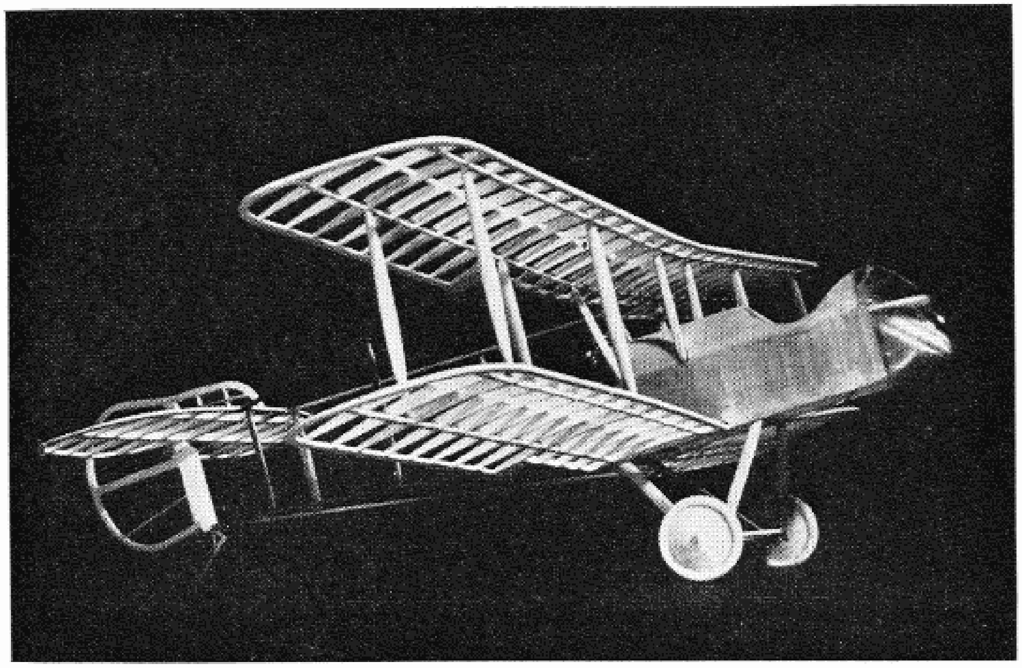


	1	2	3	4	5	6	7	8
1	61	185	145	35	24	15	12	10
2	92	170	173	45	21	18	13	10
3	89	152	175	42	22	18	12	10
4	80	153	166	22	19	16	15	13
5	52	143	176	95	33	20	16	14
AVGE	74.8	160.6	167	47.8	23.8	17.4	13.6	11.4

If the flight capsule connection is too low, liquid CO_2 will reach the cylinder head valve and this results in the engine slowing right down and little bits of ice being ejected from the exhaust ports! The length of run is also greatly reduced.

Comparison of charts **1** and **3** will clearly show the different results obtained from the alternative charging methods. In comparing gas and liquid charging patterns it is interesting to observe that whereas in the former, the first charge always results in the longest run, in the latter, the first one is always considerably shorter than the second run.

Looking at chart **1** it will clearly be seen that only three good runs are obtained from a single Sparklet bulb with liquid charges. The fourth run is



The Author's 1/24 scale De Havilland D.H.2, which lends itself admirably to CO_2 propulsion.

really too short for anything except test flying, and yet it seems a pity to throw away the bulb when there is still quite a lot of gas in it. The answer is to employ a second bulb, and after charging the flight capsule as though for a fourth flight,

As on the cover, the 14 in. wingspan D.H.2 is an impressive subject, flies beautifully and has scale construction.

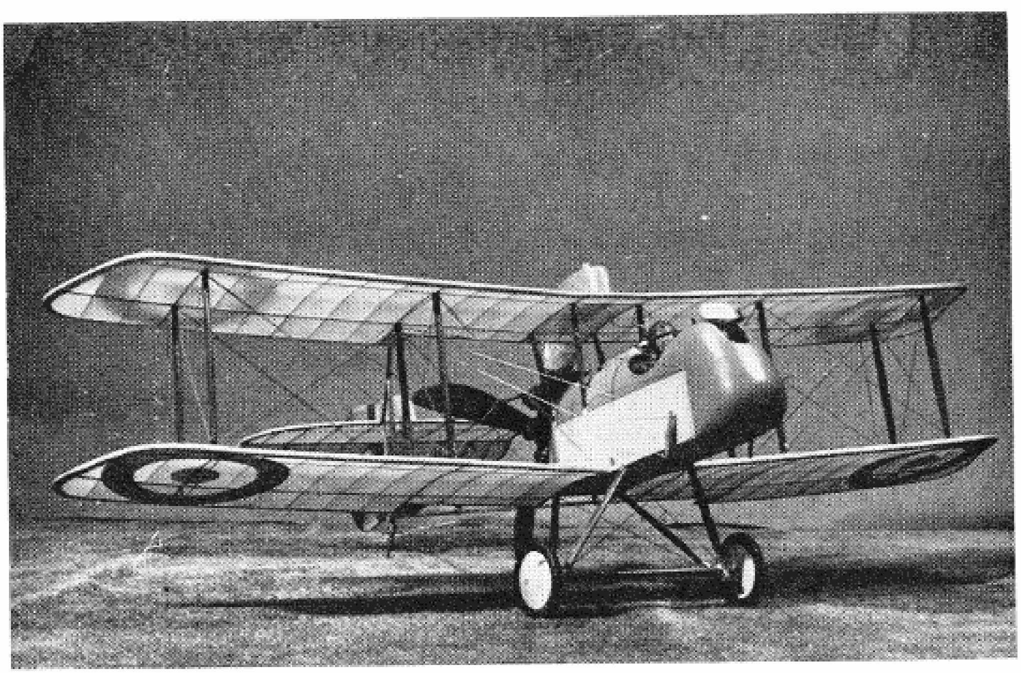
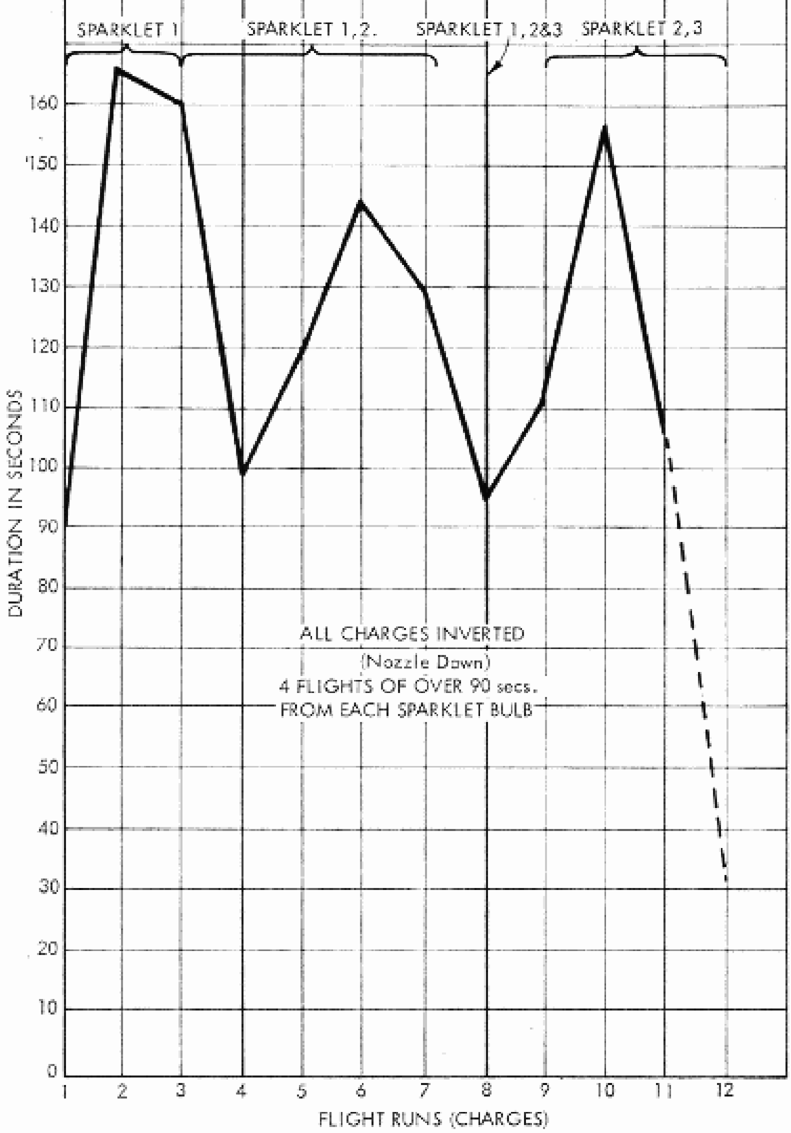


Fig 2 Use of suplementary charges

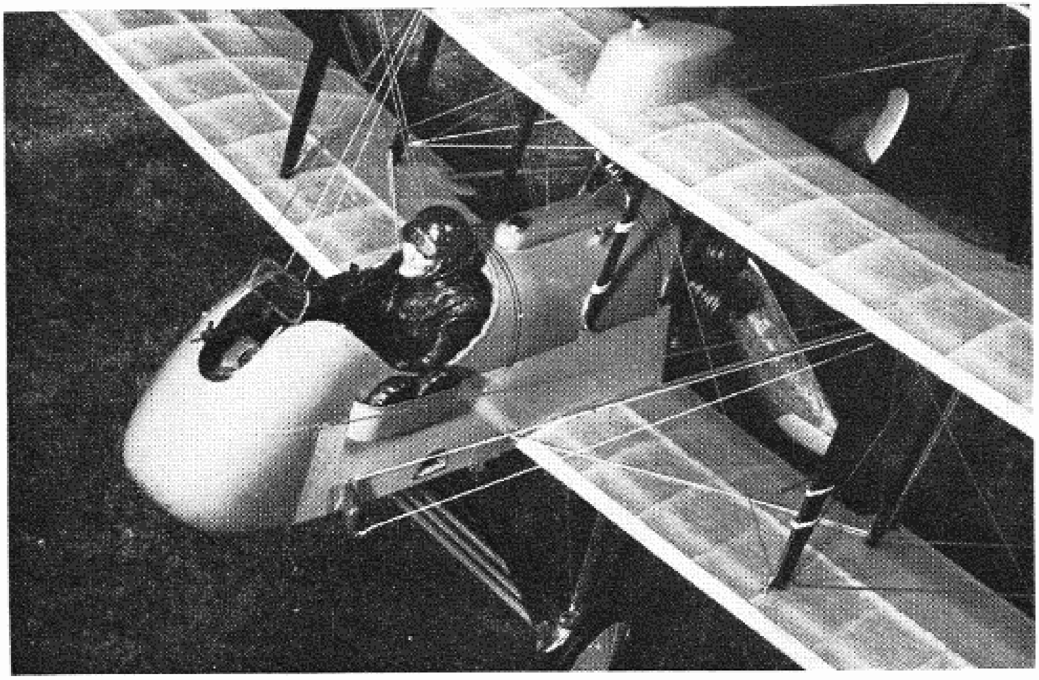


top it up from bulb 2. In this way you use less gas from the second bulb, because there is already quite a lot of gas in the flight capsule from bulb 1.

Repeat the procedure for flights 5, 6, 7 and 8, but on 8 replace bulb 1 (now well and truly drained) with a new one and pump in a charge from this one as well. Then carry on with bulbs 2 and 3 as shown in *Fig* 2.

In this way four fairly consistent runs can be achieved from each Sparklet bulb—an efficiency increase of 25 per cent. Careful marking of the bulbs is, of course, essential because the lowest numbered bulb must always be used first to avoid reverse gas flow *from* the flight capsule *to* the charging bulb!

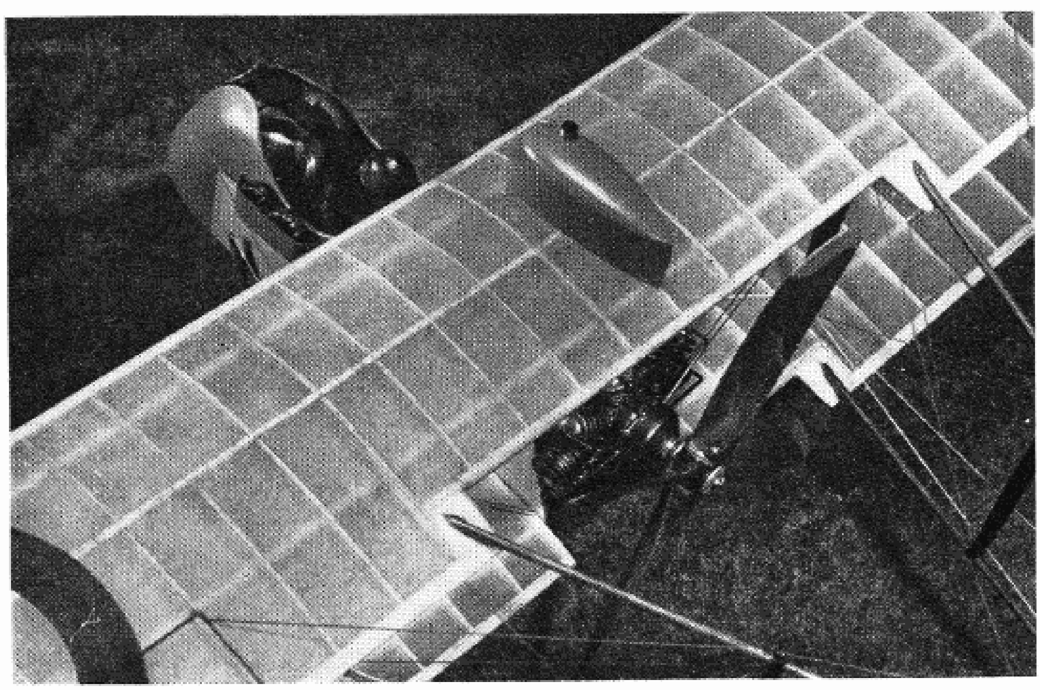
There is often little to choose between the engine runs from the *first* charge whether liquid or gas, and it is interesting to note the results obtained

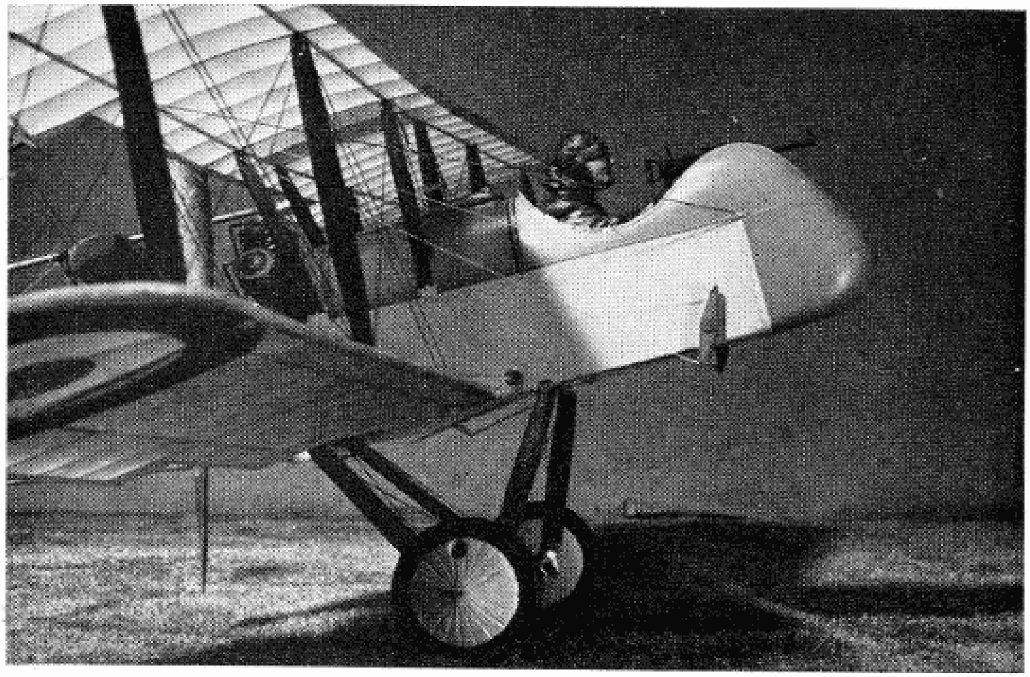


It is hard to believe that this model is only to the same scale as some plastic kits, yet it can make flights of up to two minutes on CO_2 power.

by giving the first charges nozzle up (gas) and subsequent charges nozzle down (liquid). This gives one very good extra run per Sparklet bulb, as shown in chart **4**. It is also interesting to note that during this particular series of tests,

Almost a puzzle picture—which cylinder is the real one? The CO_2 motor lends itself so well to incorporation in a dummy rotary or radial unit. The flight capsule and its charging point are in the forward part of the cockpit nacelle.





Yet one more view of the cover subject. Length of that centre nacelle is 4 in. but it completely accommodates the CO_2 flight capsule and power unit as well as a scale pilot, gun and dummy engine. Total weight of the model is little more than 1 oz.!

the longest run* of the lot was achieved in a fourth charge (over 200 seconds). The nearest to it was 185 seconds from the second charge of the series of runs on chart **1**.

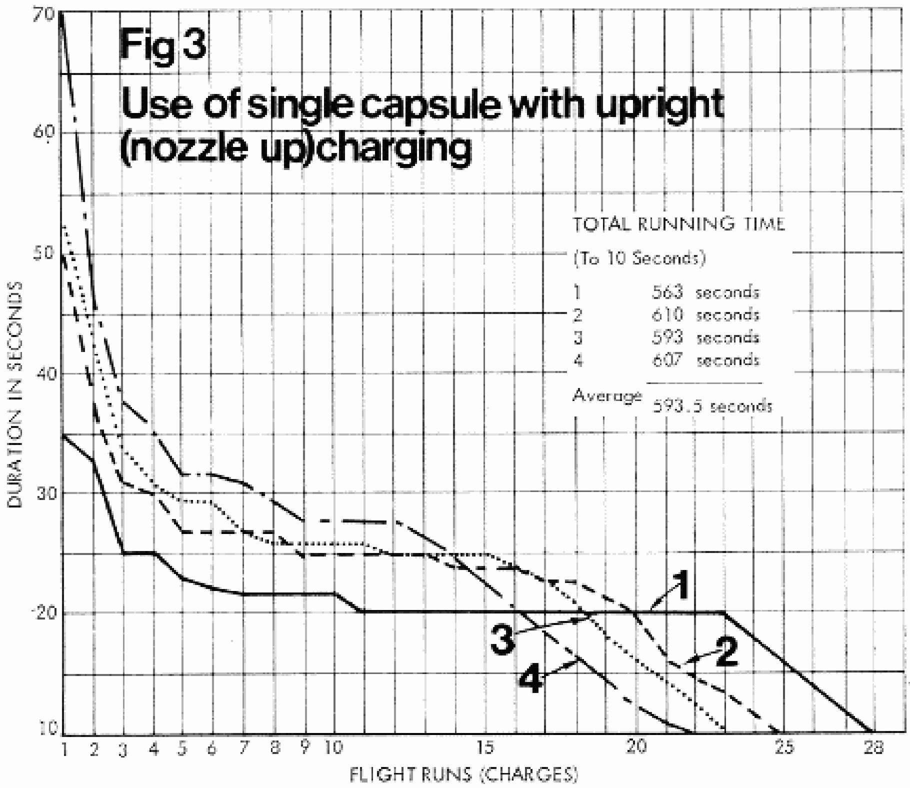
Using this mixed upright/inverted charging system a series of tests was carried out and on each succeeding one, two more runs were made with the bulb upright before inversion for the rest of the tests. Eventually, the point was reached when inversion had no effect on the expected *gas charge* time, thus indicating that only gas remained in the Sparklet bulb at this point.

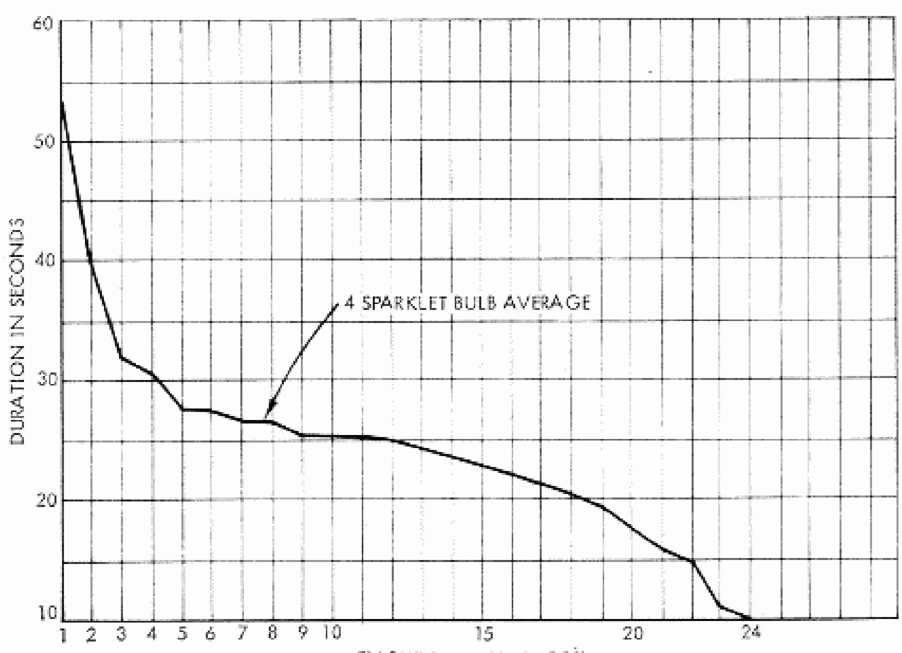
All the engine runs from which the charts in this article were made were at similar setting with the same propeller and in uniform temperature conditions.

If the model will carry an extra 3 grammes, there is another way to achieve even more usable engine running time, and that is to use *two* standard flight capsules joined together by a short length of thin copper tube. The doubling of the flight capsule volume gives much longer runs and even a gas charge can give a whole string of usable engine runs from one Sparklet bulb. Bulb 1 on chart **5** (gas only charges) gave no less than seven 80-second runs and one 110-second run.

The twin flight capsule can also overcome another problem—that of trim change, resulting from the weight of a liquid charge. There is a two-gramme difference between a charged and uncharged single flight capsule (liquid), but a gas-only charge produces no measurable weight increase. However, a *liquid* charge in a twin-capsule installation will add not only the three additional grammes of the extra capsule, but also four more grammes of liquid gas. It is an important

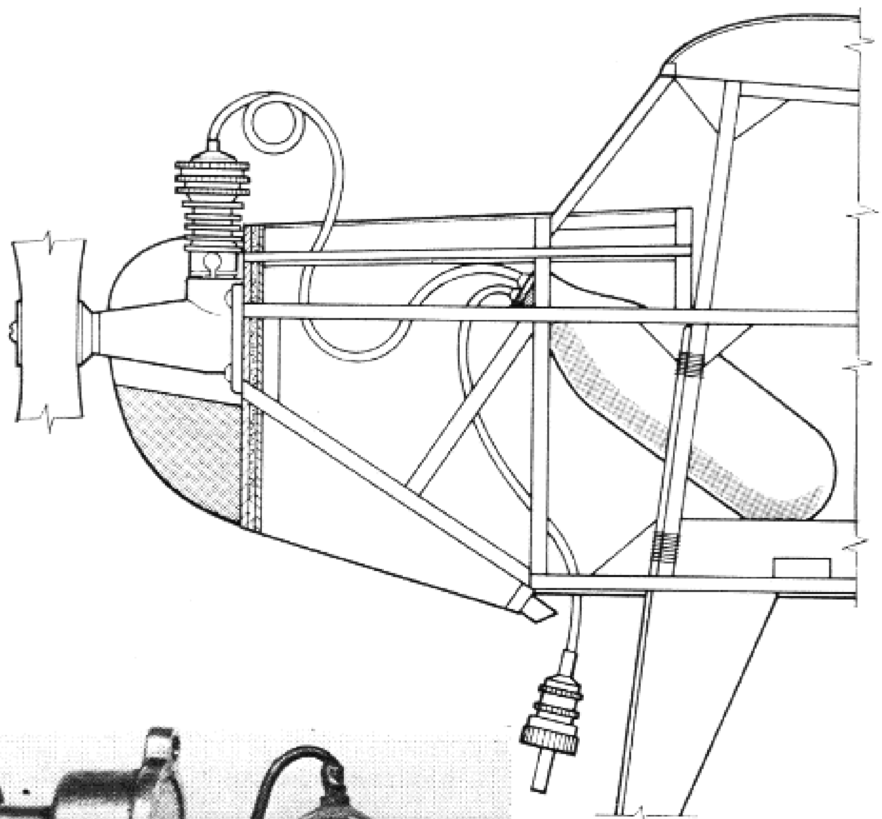
* From a single flight capsule.

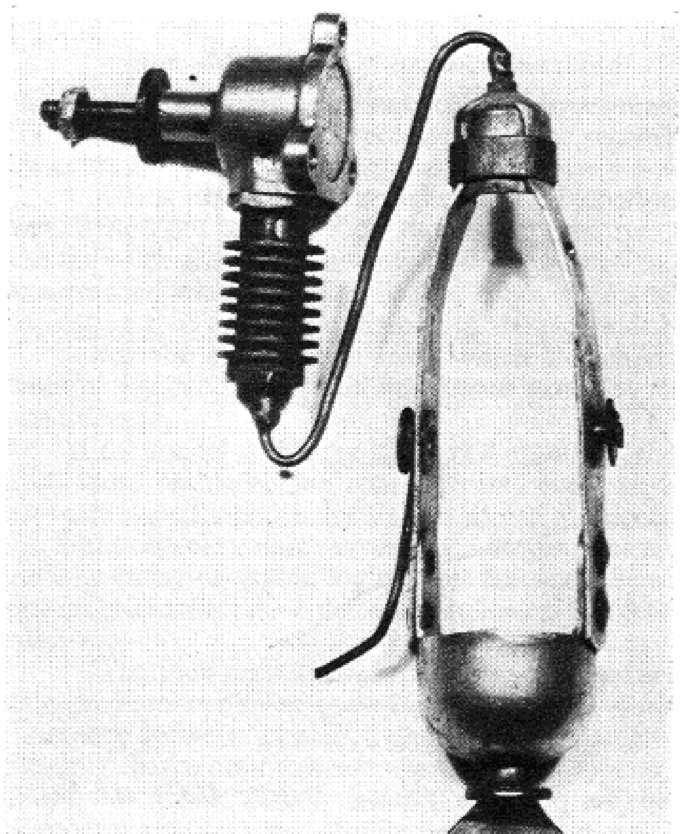




factor to consider when capsule positions relative to the C.G. are being laid out.

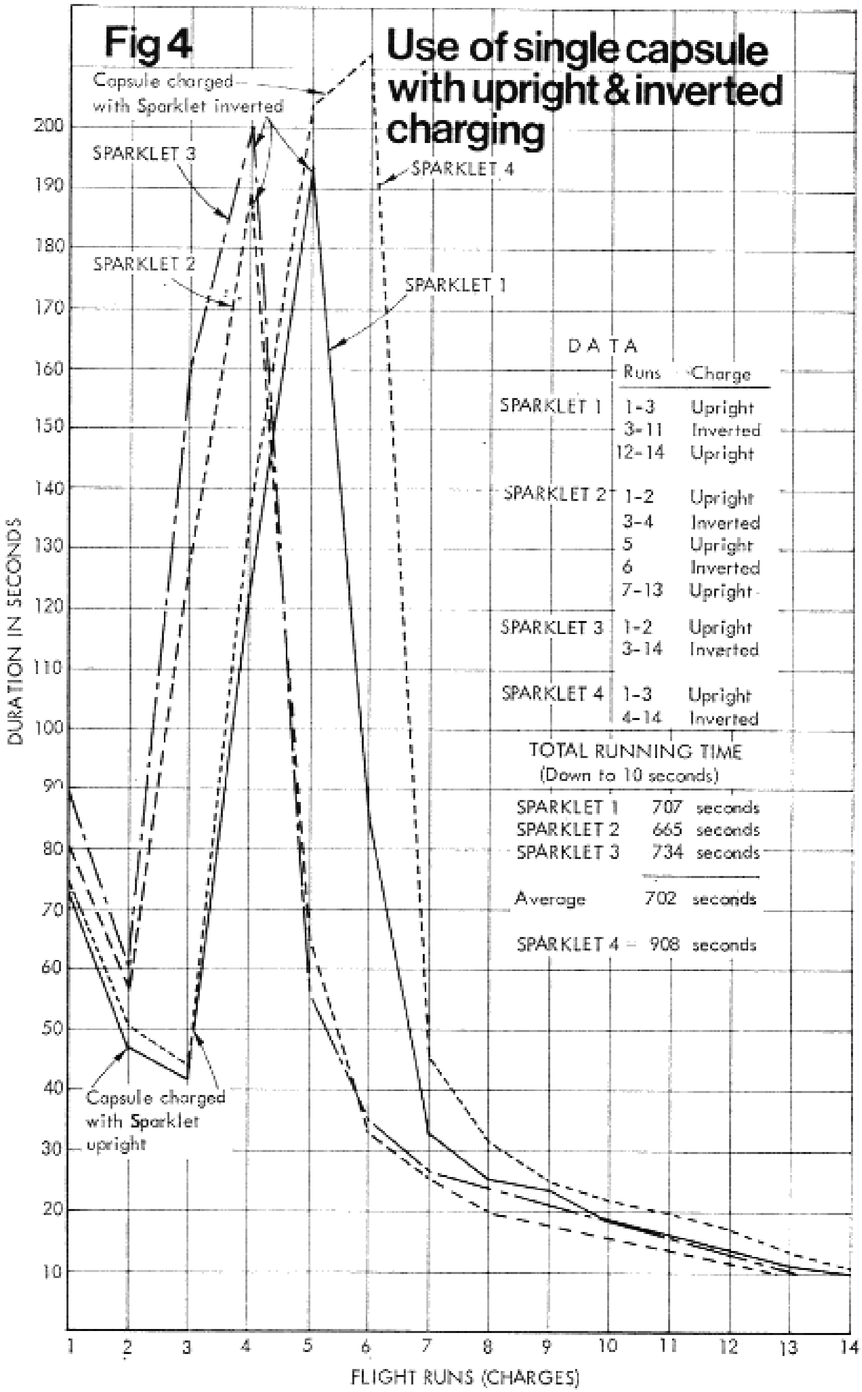
These studies clearly show the measure of control that can be exercised over the engine run by means of various charging techniques.





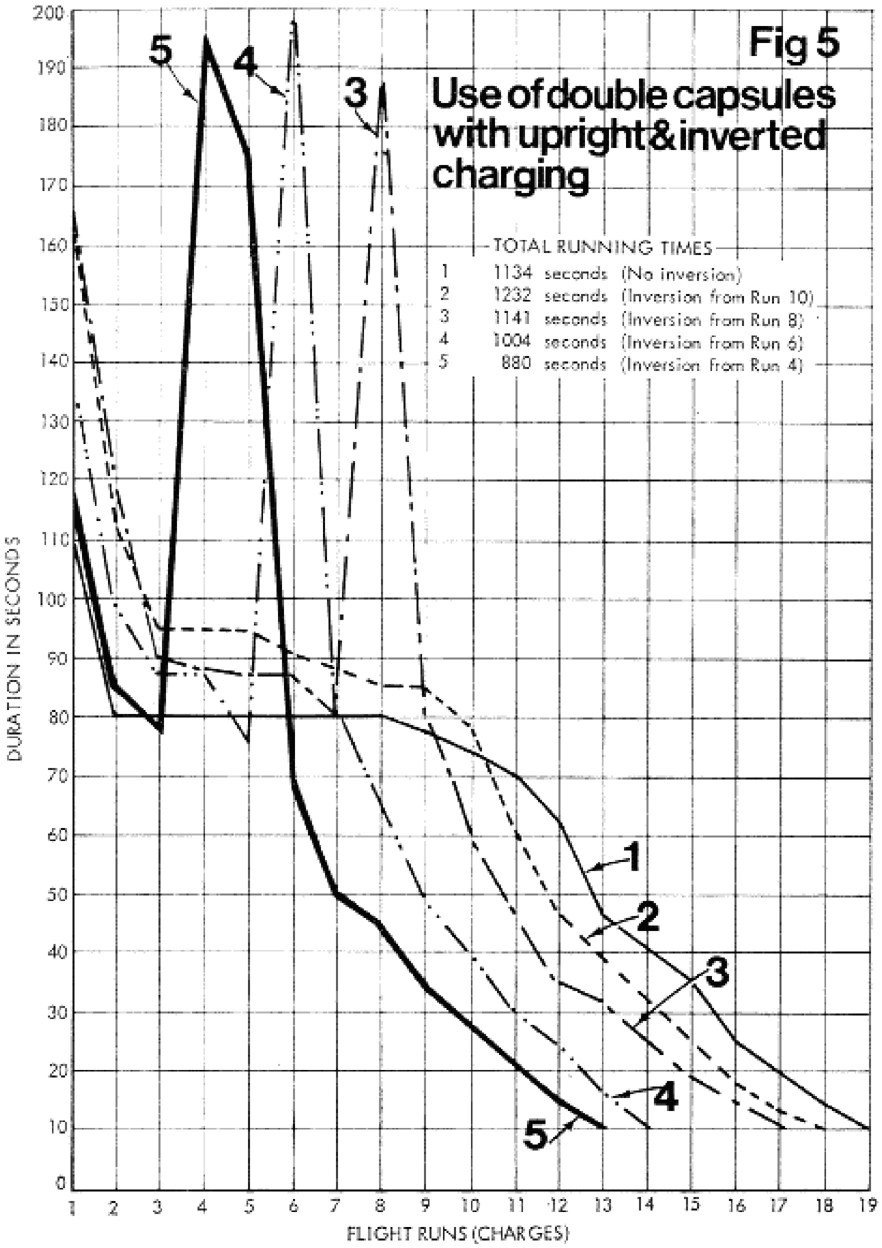
Above: Standard Brown motor installation reproduced actual size for conversion of a KeilKraft Auster Arrow without any modification to the unit. This was described by John Stennard in his *Aeromodeller* article in March 1972. Note the angle of the flight capsule.

Left: The CO_2 motor is by no means a complete novelty and has been in production, on and off, for over 40 years. The example at left is one produced by the OK Engine Company of U.S.A.; designed to carry the Sparklet bulb in a lightweight holder, as reproduced here, actual size. Various mechanical aspects have been considerably improved in the smaller Brown engine which is protected by patents and there is, of course, a tremendous weight-saving through the use of the rechargeable flight capsule.



Although there is a marked power surge upon starting the engine, it is nowhere near as acute as with a rubber motor, and the gradual reduction of power as the pressure falls produces a most realistic transition between power flight and glide.

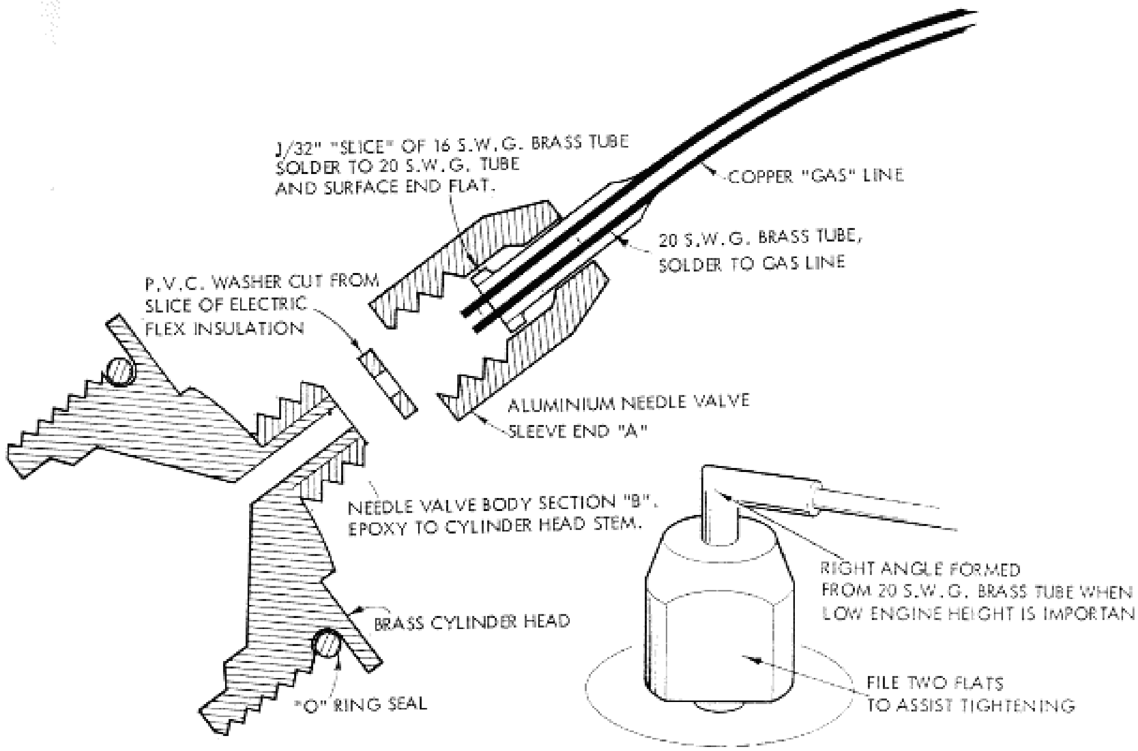
It is interesting to compare the power curves on chart **6**. Notice that even the runs from "the bottom of the Sparklet bulb", which are very much



shorter than the first one, still drive the propeller at almost maximum revs. immediately after starting.

The liquid charge, after the initial surge of power, tends to produce a comparatively flat curve for most of its power run, whereas a gas charge continuously falls off from the start to the finish.

It is worthwhile to experiment with various propeller/throttle combinations for each model. Sometimes it is better to use a large propeller and high throttle setting to achieve a given engine run and in other cases a smaller propeller at medium revs. will produce almost exactly similar flight patterns.



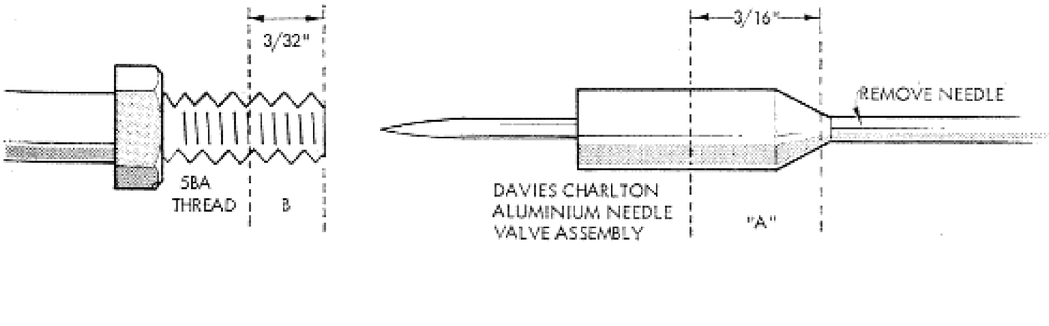
With a small propeller (down to 3 in.) something like 7,000 r.p.m. can be achieved, but duration of run at these revs. is, of course, very short.

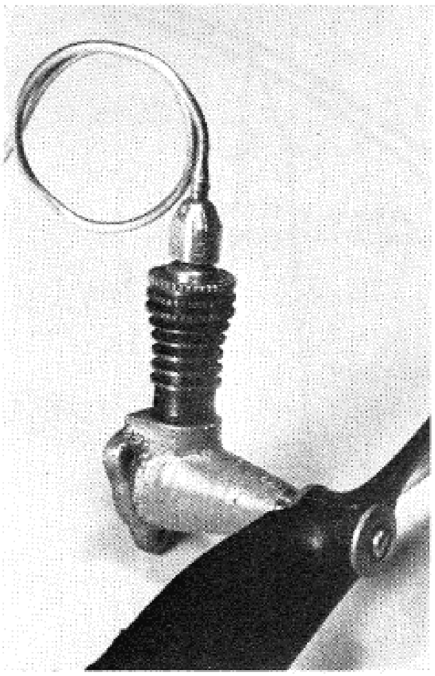
The late Howard McEntee, writing on R/C CO_2 in **Radio Control Manual No. 4,** gives further interesting leads for those wishing to experiment. He describes exposed coils of copper gas pipe between engine and capsule to assist efficient gas expansion and mentions experiments with heat generators which, when used in this section of pipe, would enable the engines to be used efficiently in cold weather when the ambient air temperature is too low (below 50°F) to allow adequate gas expansion.

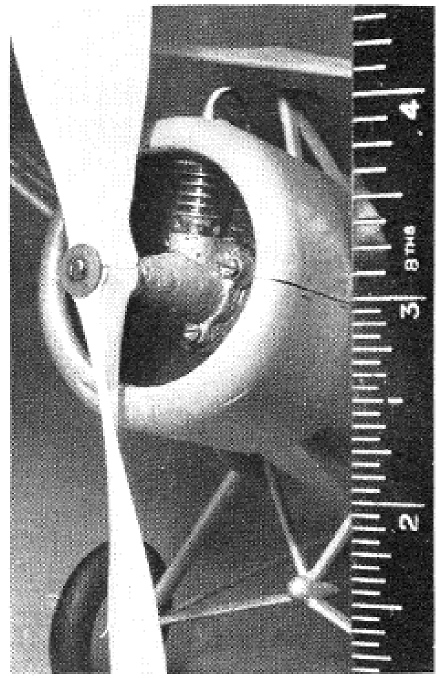
Bigger charging bottles—such as CO_2 fire extinguishers—would make tests of the sort here described of purely academic value (besides considerably reducing the cost per flight), but probably most users will find the convenience of the little Sparklet bulb a great asset.

Airframe Adaptability

Airframes for these comparatively expensive little engines are so cheap and quick to build that it is essential to have the power plant easily transferable between models.



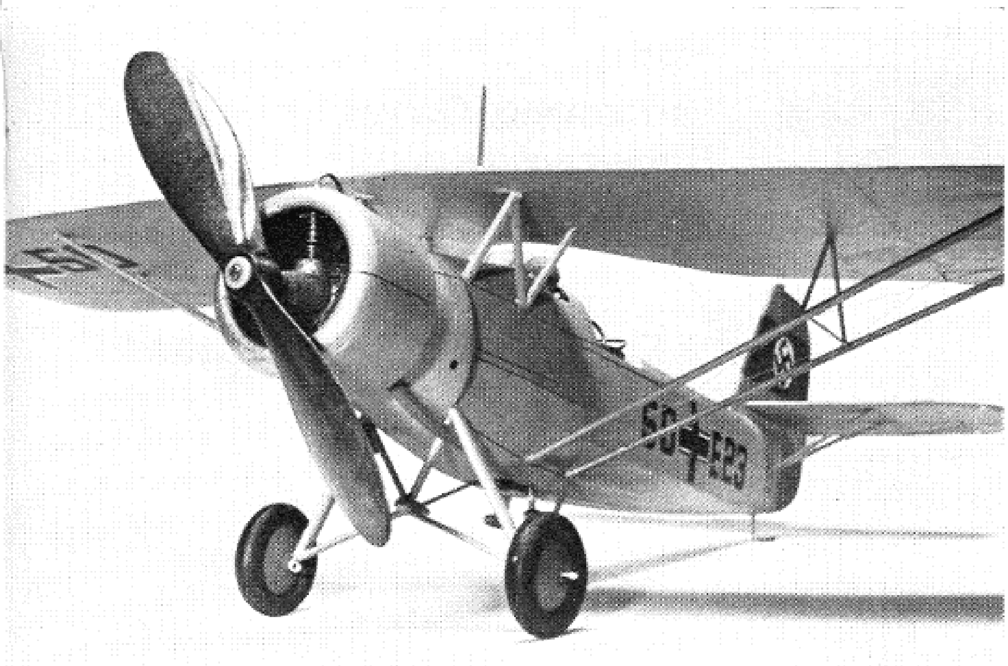




Having said this, there are nevertheless occasions when the flight capsule can only be built into the framework in an inaccessible position, and if the gas pipe is then permanently attached to the engine, it becomes impossible to change the engine unless you have some spare cylinder heads which you can leave attached to the permanently installed gas pipe.

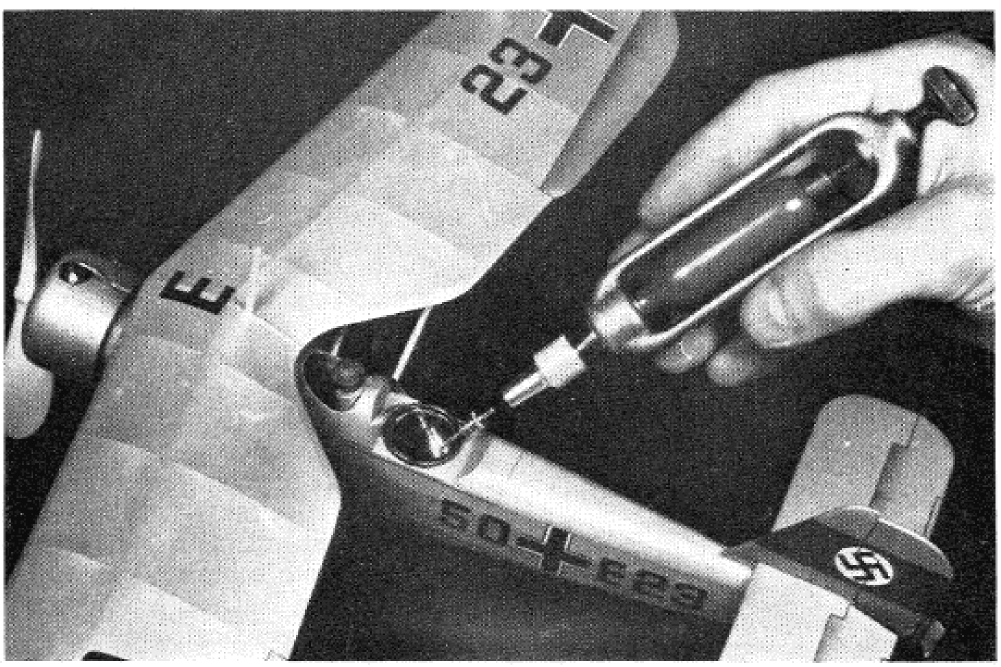
To overcome this problem I have devised a simple means of attaching and detaching the gas pipe from the cylinder head requiring no machining, and the details are shown on page 15.

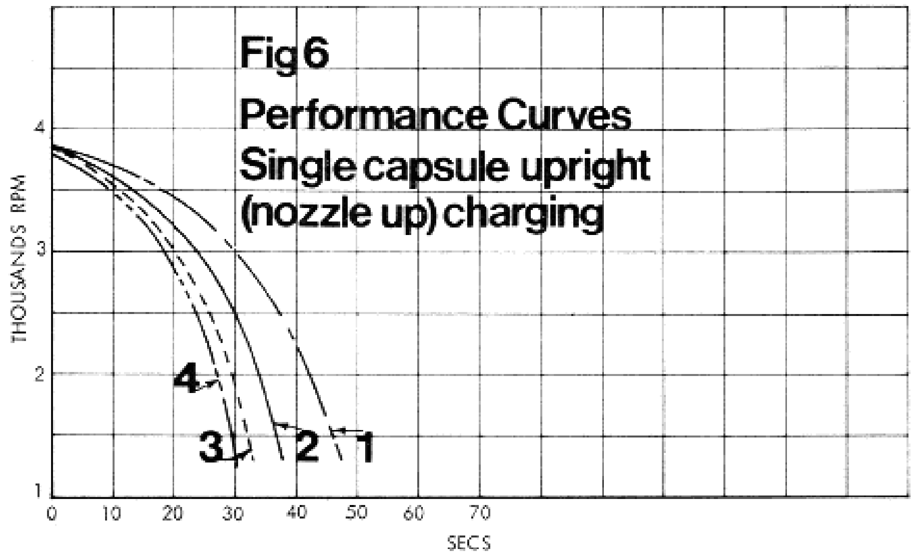
Above left and immediately left: Two views which illustrate the Author's conversion of the cylinder head for practical operation in more than one model. The conversion uses parts of a Davies Charlton aluminium needle valve assembly as sketched on previous page. Above right: Almost actual size view (note ruler) of the Heinkel He 46 with the Williams Brothers nylon prop supplied with the engine; and above opposite: Doug McHard's specially carved wooden propeller, which improves performance. Immediately right is the Heinkel being charged, using the Brown charging unit with a standard British Sparklet bulb, the flight capsule fitted in this case to the rear cockpit.

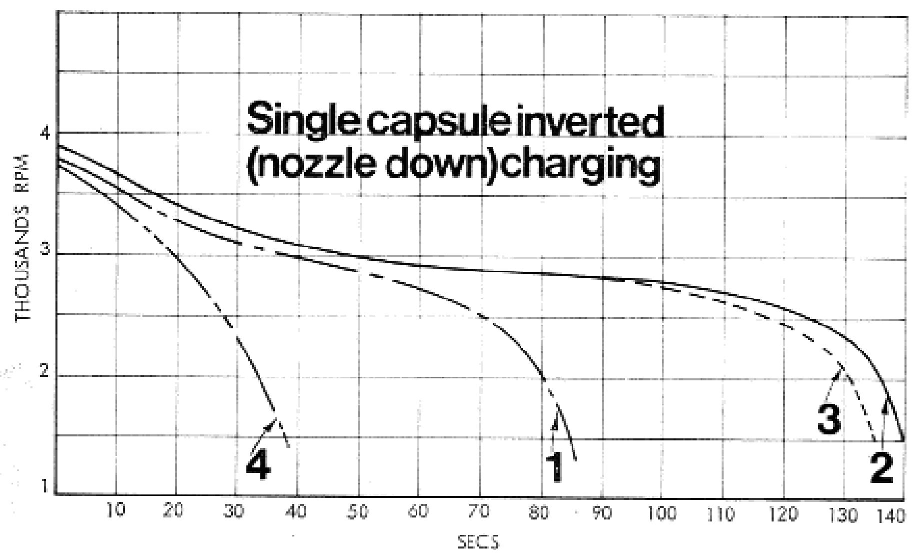


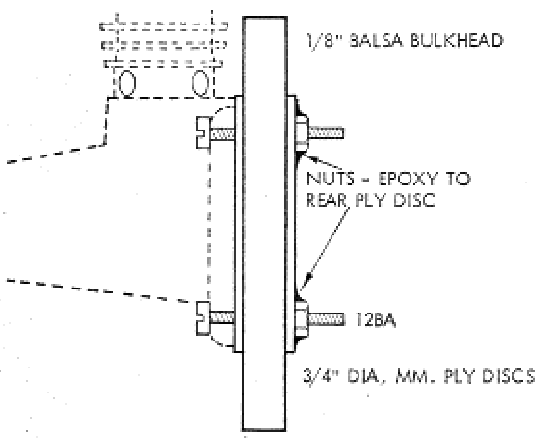
If you have some modest workshop facilities an even neater job can be made using a section of brass 6 BA bolt drilled and then soldered over the cylinder head tube and a 6 BA tapped length of thick-wall brass tube with a 6 BA screwed insert in the top end in place of the aluminium needle valve sleeve.

Make sure that the soft PVC washer is a tight fit within the sleeve. It is also important to ensure that the washer faces are cut parallel and flat—use a









sharp razor blade. If you can countersink the two faces butting against the washer a more efficient gas seal will result. An incidental but significant advantage of this attachment is that it enables the cylinder to be more easily rotated to adjust the engine revolutions.

I have carried out a number of experiments with various propellers, both commercial and hand carved. On balance, I believe that the most practical propeller for

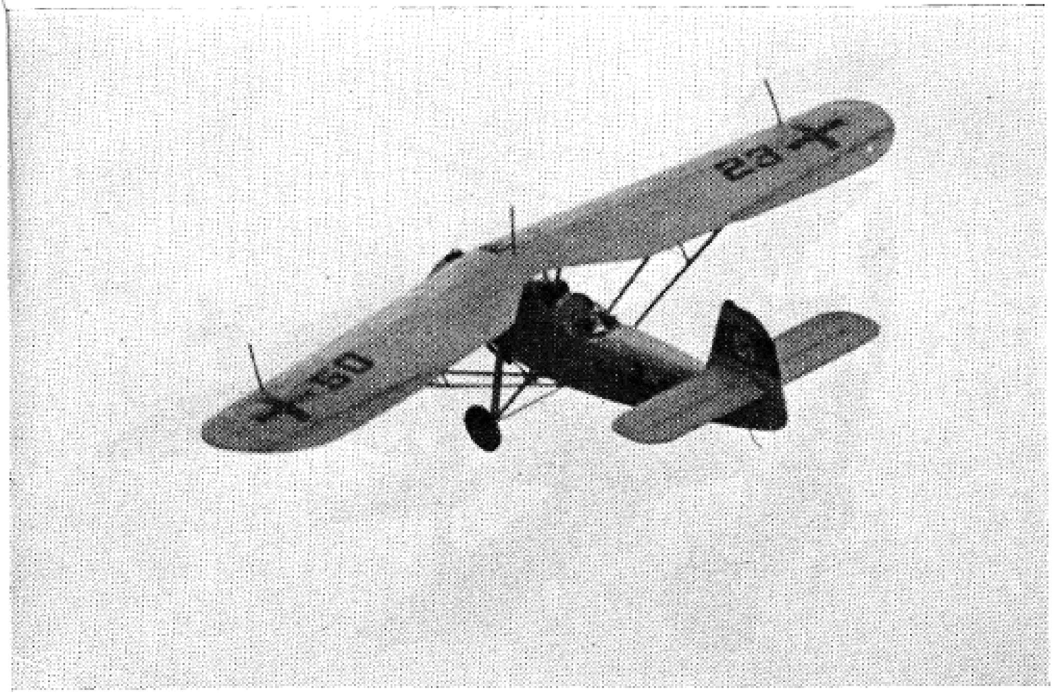


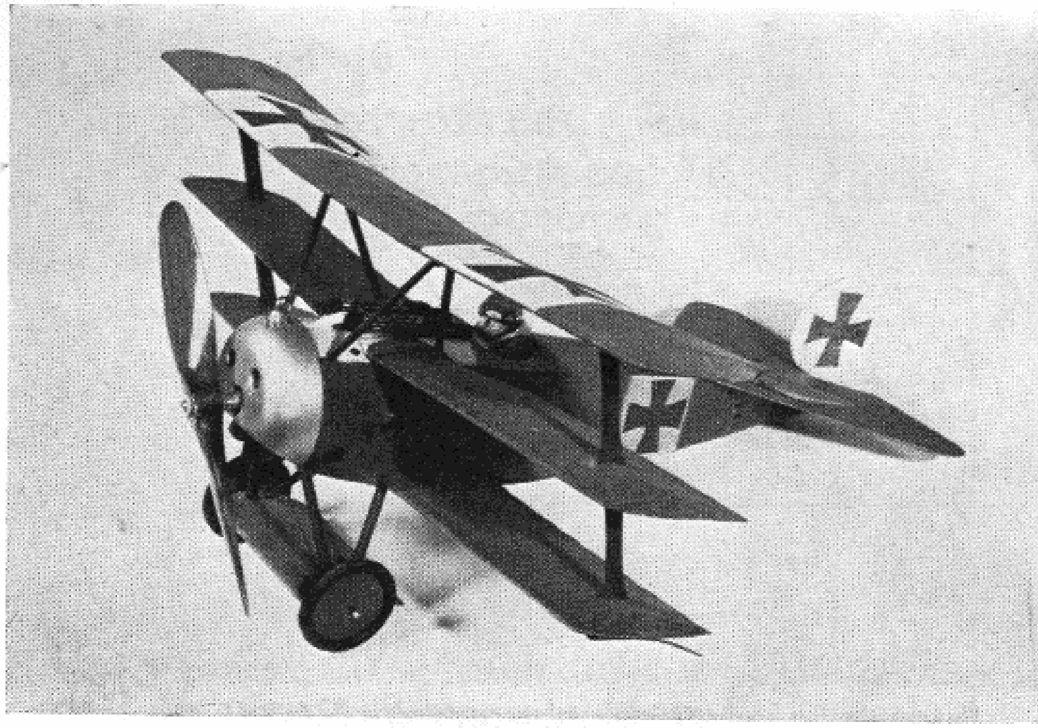
Fig 6 opposite: It is interesting to note that the revolutions at the start of each run remain very consistent despite the subsequent wide variation of total running time. Above: Fine view of Doug McHard's Heinkel He 46, climbing away for another long flight on a calm summer evening with the flutter of the CO_2 motor providing a realistic muffled sound.

the average flier is the 5½ in. Williams Bros. nylon prop. supplied with the engine. I have wooden props that are more efficient but it must be admitted that their rigidity is likely to bend or even break the thin prop attachment bolt following a turn-over landing. The He 46 likes the plastic prop diameter reducing to 4¾ in. for optimum performance.

The cover subject D.H.2 was built as an example of the type of aeroplane now made possible by the CO_2 engin^, which with rubber power would be impractical and for free flight power would require dead ballast weight to achieve the correct C.G. No ballast weight is used in the D.H.2, which weighs just a fraction over one ounce in flying trim. First time never-miss starting in that cage of booms and wires is also a valuable "plus" and the total absence of fuel mess means that you can really build like a rubber model. The absence of engine scream produces a wonderfully realistic effect in flight.

The Heinkel He 46 shown here is 19 in. span and has a flying weight of 22 grammes (about ¾ oz.). The engine is adjusted to turn at about 3,250 revs. (upon starting) and this produces a gentle climbing flight which, on a single flight capsule with a liquid charge, will give durations of around 1½ minutes. Incidentally, these settings were used for the tables in this feature.

The He 46 is, of course, an adaptation of the rubber powered original (plans for which appeared in *Aeromodeller*, April 1970), and one reason why it was originally chosen for rubber power was its relatively long nose, which distributes the rubber weight more efficiently about the C.G. No such design limitations exist with a CO_2 engine and, in fact, a short nose layout has certain advantages, for it removes the temptation to move the flight capsule to and fro along the fuselage to achieve the correct C.G. If the flight capsule, because of a



The 11½ in. wing span 1/24 scale Fokker Triplane—never an easy subject to fly—becomes much more practical through the use of the Brown CO_2 power unit.

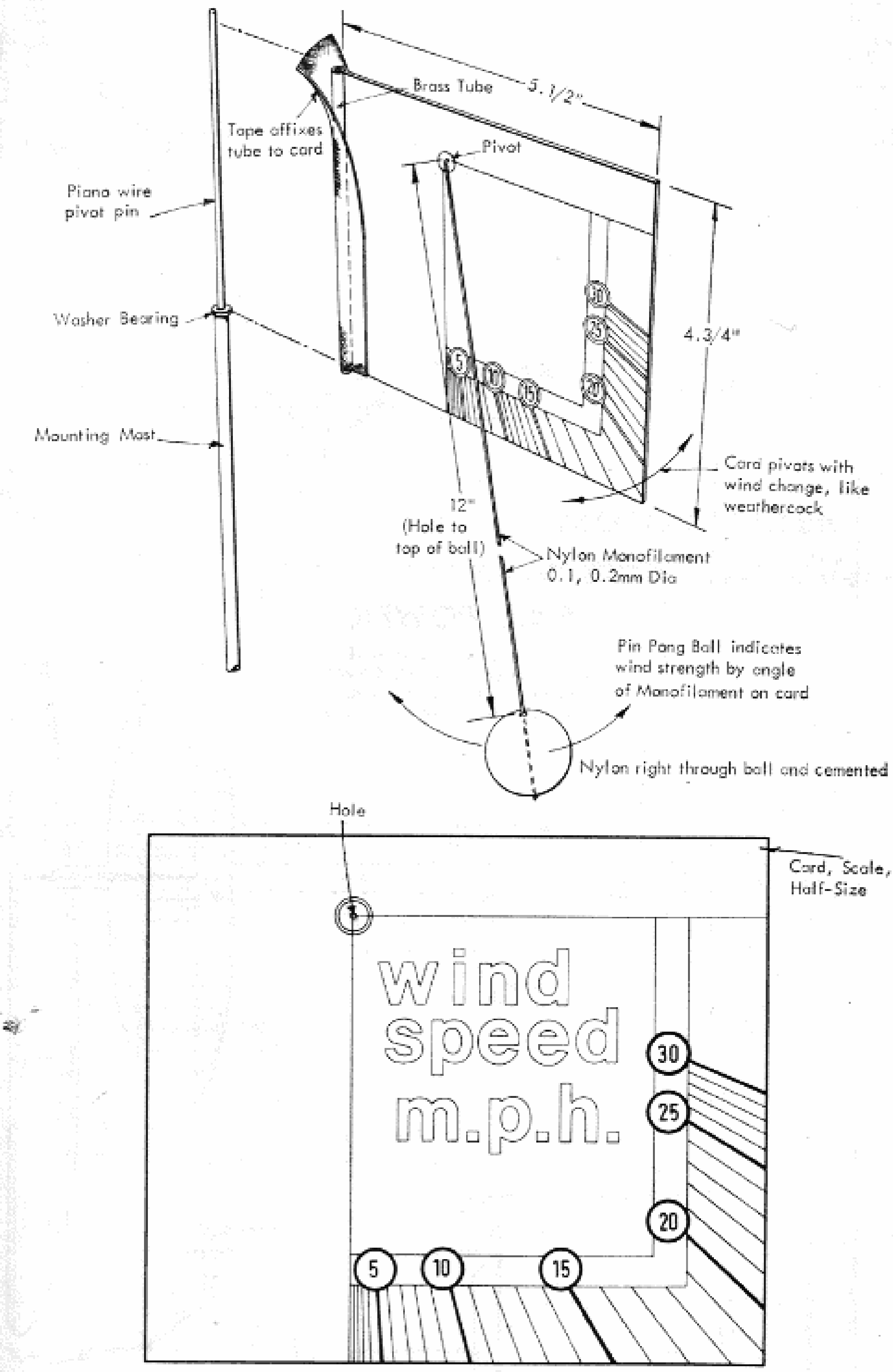
long nose, ends up too far to the rear of the C.G., the weight of a liquid charge can seriously upset the power trim. It is better always to locate the flight capsule as near as possible to the centre of gravity or, as mentioned earlier, use twin bottles.

It would be difficult to find a shorter nosed subject than the Fokker Dr.1 Triplane, which is another subject in which I have installed the Brown Junior. This was originally a rather unsuccessful rubber model which has been made completely practical by the use of CO_2 power. Scale is 1/24, which makes the wingspan approximately 11½ in.

"Difficult" Types become "Possible"

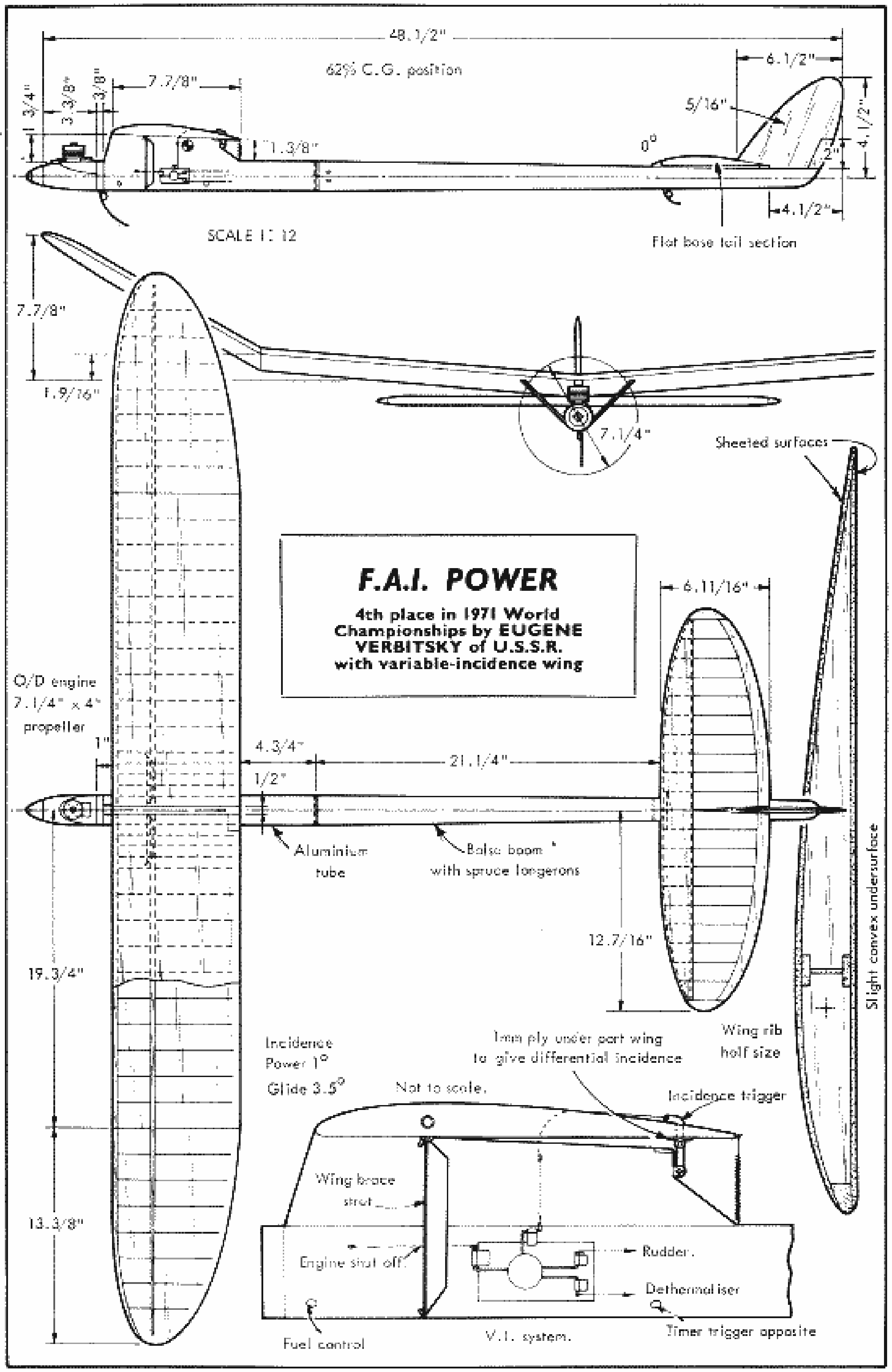
The choice of model for this new engine is wide to the point of being virtually limitless. Types which leap to mind as tempting projects, previously difficult or impossible for rubber power, are the whole range of interesting short fuselage types like the D.H.2 on the cover, the Westland Pterodactyls and a host of flying wing prototypes such as the Waterman Arrowbile. All those early flying machines with lots of frame and very little fabric like the Bleriot Monoplane Model, which always looked wrong with a rubber motor showing through the rear fuselage.

How about all the twin and multi-engine types which are immediately ideal with a central flight capsule linked to both engines (all four if you are a millionaire)? The Brown Junior CO_2 engine will run quite happily in either direction so all torque problems can be overcome by counter-rotating props! Alternatively, differential throttle settings will enable torque effects to be fully countered and all engines from a common capsule *must* stop at the same time!

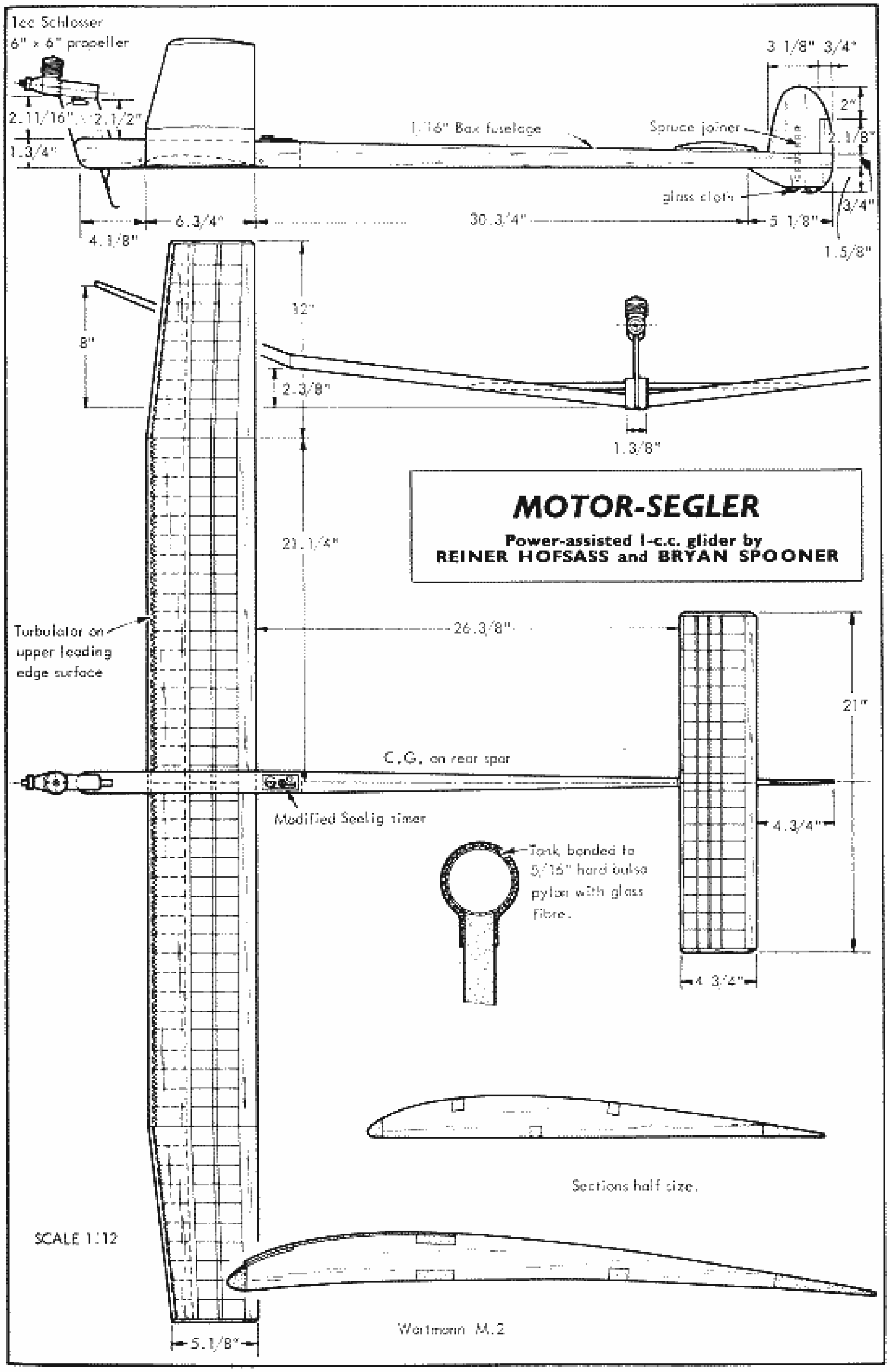


PENDULUM ANEMOMETER
reads to within 10% of actual values

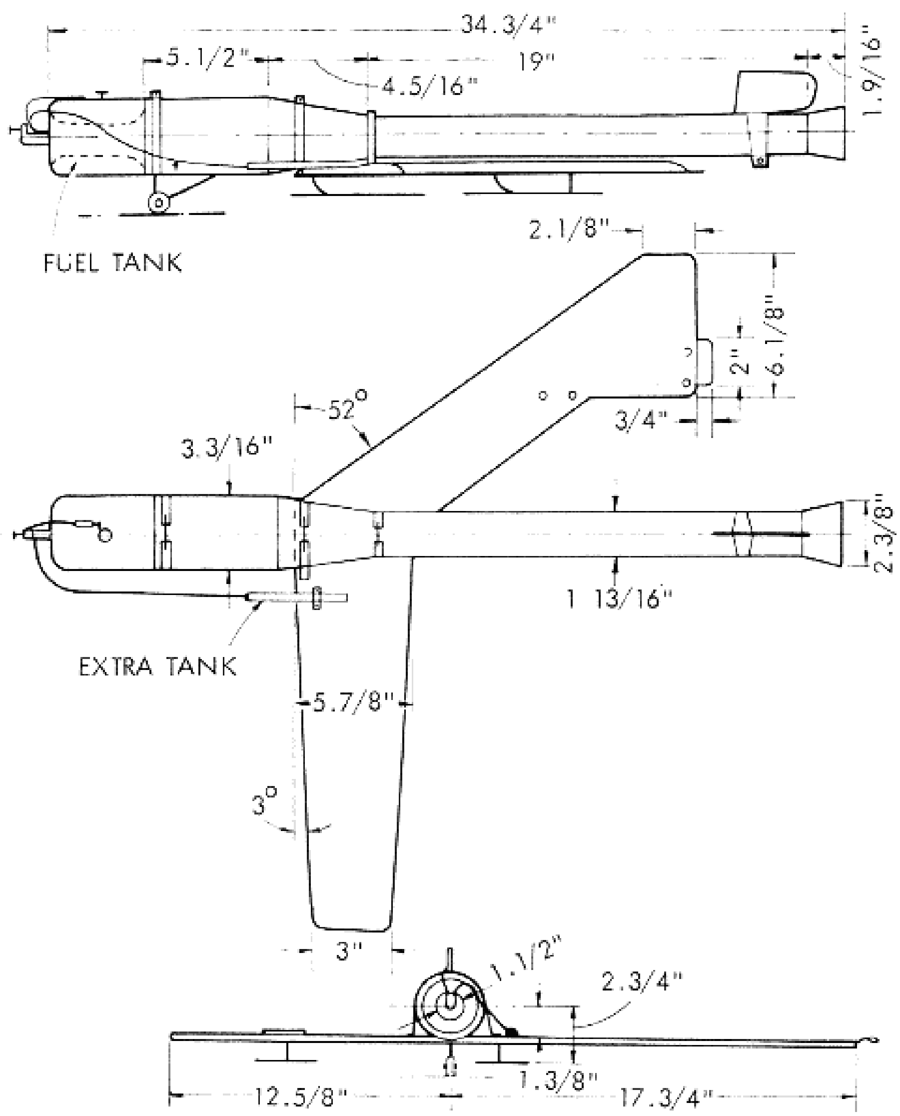
SCIENTIFIC AMERICAN/LSMFT USA


48.1/2"
62% C.G. position
6.1/2"
3/4"
3.3/8"
3/8"
7.7/8"
1.3/8"
5/16"
0°
4.1/2"
2"
4.1/2"
SCALE 1: 12
Flat base tail section
7.7/8"
1.9/16"
7.1/4"
Sheeted surfaces
F.A.I. POWER
4th place in 1971 World Championships by EUGENE VERBITSKY of U.S.S.R. with variable-incidence wing
6.11/16"
O/D engine
7.1/4" x 4" propeller
1"
4.3/4"
1/2"
21.1/4"
Aluminium tube
Balsa boom with spruce longerons
12.7/16"
Slight convex undersurface
19.3/4"
Incidence
Power 1°
Glide 3.5°
1mm ply under part wing to give differential incidence
Wing rib half size
Not to scale.
Incidence trigger
Wing brace strut
13.3/8"
Engine shut off
Rudder.
Dethermaliser
Fuel control
V.I. system.
Timer trigger opposite

MODELLBAU



FREE FLIGHT NEWS



RECORD SMASHING JET—FASTEST MODEL IN THE WORLD

by L. Lipinsky, U.S.S.R.

My record-breaking control line model reached a speed of 395·64 km/hr. (245·8 m.p.h.) on December 6th, 1971. It has a wing area of 160 sq. in., a wingspan of $30\frac{3}{8}$ in. and weighs, ready to fly, $34\frac{1}{2}$ oz. Its main fuel is petrol B-95, which accounts for 5 oz.; the engine is 17 oz.; afterburner fuel (spirit 66%, water 33% and methanol 1%) weighs 0·7 oz.; so that maximum loading is about 30 oz. per sq. ft.

This asymmetric flying wing was designed by S. Zhidkov. It is made of balsa and linden and covered with silk. Some of the surfaces are covered with asbestos paper 0·4 and 0·2 mm thick for fire protection. The engine is mounted on two stainless steel brackets 0·6 mm thick and 8 mm wide. The fin is made of 0·2 stainless steel and bent at an angle of 5–6°.

For take-off and landing there is a 1-in. diameter dural nosewheel and two wire skids on the wings, each of 16 gauge. The pulse-jet engine is of special construction. Its length is $34\frac{3}{4}$ in. Diameter of the combustion chamber is $3\frac{1}{8}$ in., the diameter of the resonance tube $1\frac{13}{16}$ in. and the diameter of the air intake $1\frac{1}{2}$ in. Angle of the cone is 13°. The valve has ten petals, each 0·3 mm thick (precipitation hardened EI-702 steel). The combustion chamber, resonance tube and cone are from EI-702 steel, precipitation hardened after welding.

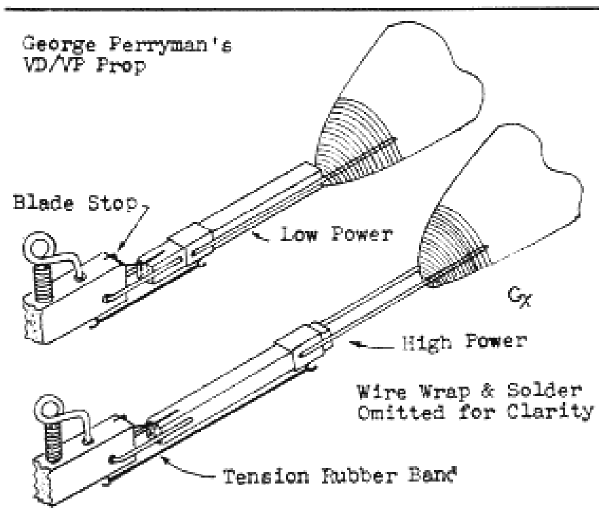
This was done as follows: the tube was left in a muffle furnace for 3–$3\frac{1}{2}$ hrs. at a temperature of 690–710° and allowed to cool down with the furnace. The steel becomes springy, which enables engine power to be increased, since the wall of the combustion chamber is less likely to be deformed when gases are pulsed out. Behind the valves on the internal wall of the combustion chamber a cone made of EI-702 steel is welded in place; it is $\frac{9}{16}$ in. wide, with an angle of 45°, the narrow end pointing towards the rear of the engine. This cone is used for deflecting and reducing the shock wave effect on the valves, and also for directing fresh fuel to the centre of the combustion chamber. The space factor of the combustion chamber is increased and combustion of fresh fuel is slightly retarded; fuel is deflected away from the walls of the combustion chamber into the resonance tube.

The main fuel tank is pressed from 0·8 mm aluminium alloy and rubbed down with emery paper to a thickness of 0·4 mm. The right-hand half of the tank is filled with balsa which has been soaked in K.153 resin, and contains a sump with a built-in filter. Petrol fills only the left-hand half of the tank. The carburettor is axial and has ten 0·8 mm openings.

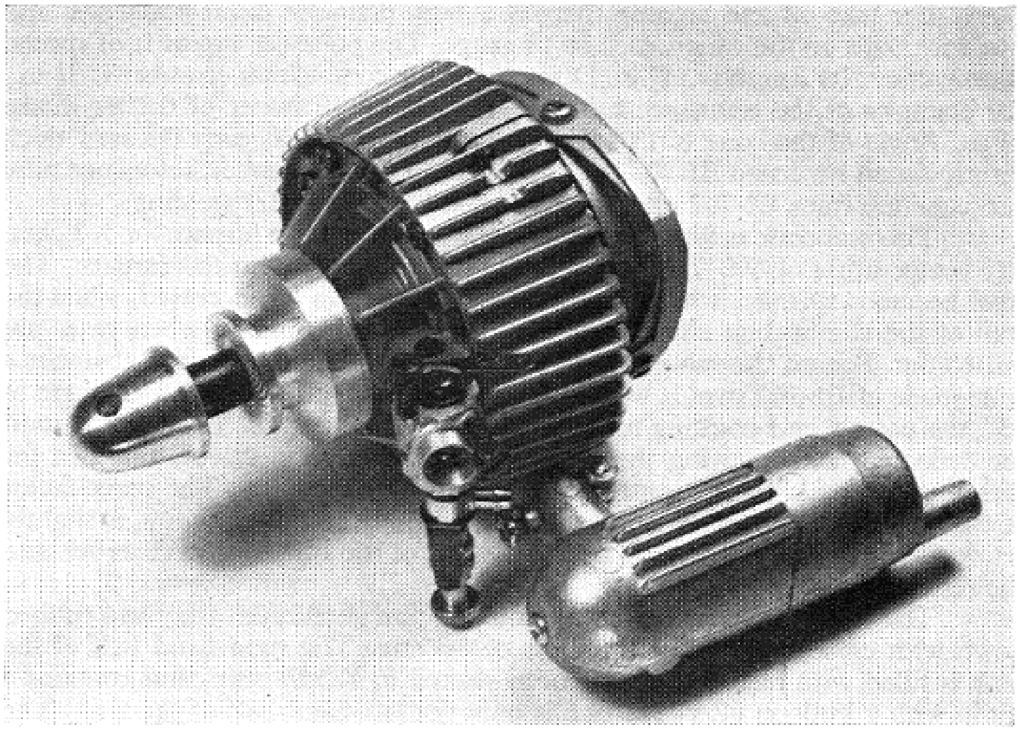
To obtain the resonance frequency the afterburner is moved along the axis. The engine can be started by moving this afterburner right up to the engine grill and then right away from it. In ordinary operation the engine is reliable, but the thrust it develops is insignificant—about 1 lb. By moving the afterburner along the diffuser, I have obtained a thrust of over 11 lb. using an additive.

The secondary fuel tank is mounted on the wing. It comes into operation with centrifugal effect. The afterburner fuel flows from two 0·3 mm holes in this tank—these are located an inch in front of the main burners. A spark-plug is used for starting the engine.

This translation from "Wings of the Fatherland" explains part of the story of the achievement. The "afterburner" and method of control remain a mystery, although the former appears to be a device for introducing additional fuel once in flight, in the same way as a conventional speed model employs a centrifugal fuel switch. Control seems to be non-existent, the model being flown on a single line, relying on the pre-set trim tab to remain airborne.—Editors.



This clipping from FREE FLIGHT, the National Free Flight Society Digest (U.S.A.), March-April issue, 1972, is a self-explanatory experiment in variable diameter and variable pitch propellers for rubber-driven models. George Perryman has never been one for convention and this device may give inspiration to further developments. The slider must of course be a smooth-riding fit in the square section guide for full effectiveness.

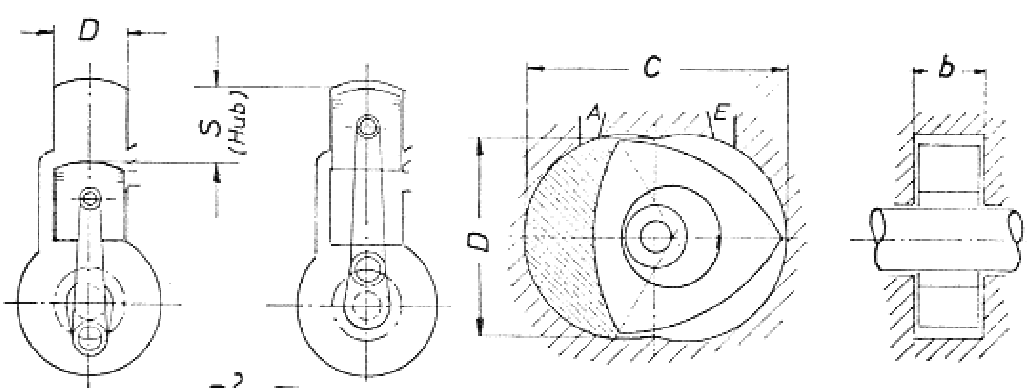


DISPLACEMENT OF THE NSU-WANKEL ENGINE

In December 1971 the CIAM (Models Commission of the FAI) accepted a proposal that the rotary piston engine be admitted into contests. Here is the supporting document.

THE status of development presently achieved with the rotating combustion engine, NSU-Wankel, necessitates a classification. The swept volume is considered as basis for motor-sport events and in some countries defines the vehicle taxes for cars. In the aeromodelling world the FAI has now recognised the Wankel engine as defined by the following description of swept volume.

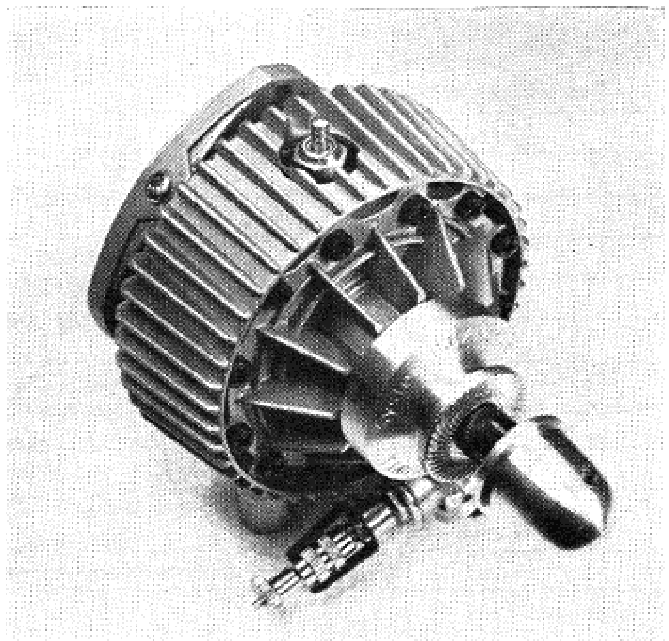
The NSU Motorenweke Aktiengesellschaft at Neckarsulm, which has developed this type of engine, and the Daimler-Benz AG at Stuttgart, which



$V_{hub} = \frac{D^2 \cdot \pi}{4} \cdot S$

$V_{hub} = 0{,}325 \cdot (C^2 - D^2) \cdot b$

Fig. 1



Left and right: The latest version of the O.S. 5 c.c. Wankel motor, seen with its silencer. Engine is remarkably quiet when so equipped . . . maybe it's the answer to the flying field noise problem. Performance of latest version is considerably improved. The ground surfaces of the rotor chamber front plate (and backplate) are now aluminium instead of metal-sprayed steel.

has studied this development from its beginning and for a long time has tested engines of its own design, consider the definition of swept volume as follows:

1. *Definition of displacement*

Generally, piston engines are prime-movers in which an expansion process inside a sealed volume is utilised to generate torque on a power take-off shaft.

The rotating combustion engine must be considered a piston engine according to this definition. The variable volume working chamber is achieving a max. and a min. size.

The swept volume means the difference between a max. and min. size of the working chamber. For the reciprocating engine the swept volume per cylinder is calculated by

$$V_z = \frac{\pi D^2}{4} \cdot S$$

For the NSU-Wankel engine the working chamber is changing between a max. and a min. size. The displacement is defined by following formula:

$$V_H = 0{\cdot}325(C^2 - D^2)B$$

whereby:

$$C = 2(R + E + a)$$
$$D = 2(R - E + a)$$

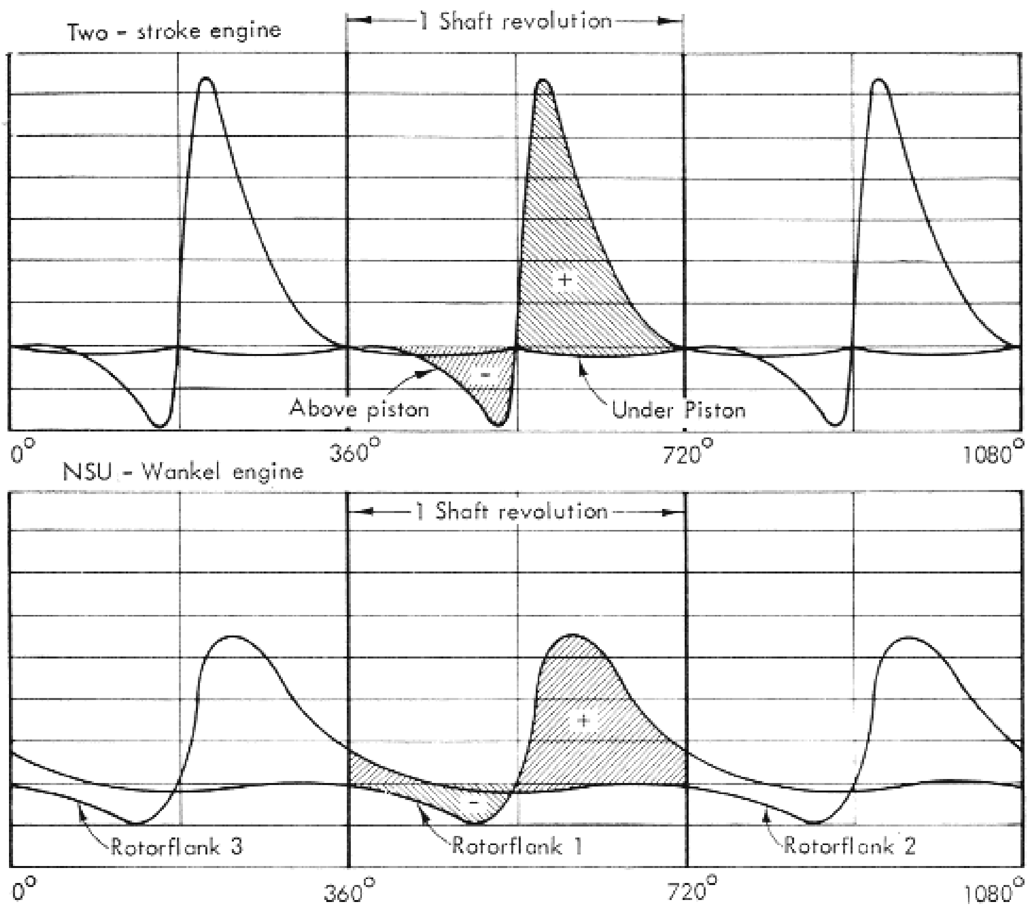
factors C, D and B can easily be measured and controlled (*see Fig.* 1).

2. *Multi-cylinder engines*

By combining several cylinders with a corresponding number of pistons, each cylinder having its own intake and exhaust ports and a separate means for ignition, a multi-cylinder engine may be established. In all cases it may be split up to a one-cylinder engine. The rotating combustion engine with one rotor and one housing shows only one intake port, one exhaust port and one spark plug. It must be considered as a one-cylinder unit.

TORQUE DIAGRAMS

Fig. 2



Only by joining several trochoidal housings (cylinders) in which several rotors (pistons) are working may it be built up to a multi-cylinder engine.

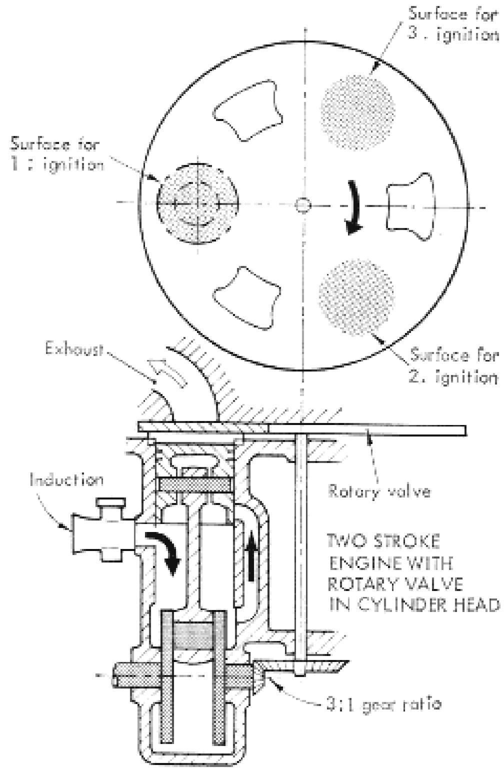
3. *Working process*

It is the purpose of each combustion engine to generate torque by the expansion of the burned gas. The expansion stroke is the target for the preparation of which several auxiliary operations are necessary. These auxiliary operations, which are called intake, compression and exhaust stroke, may occur above the same side of the piston and within the same chamber in which the expansion stroke takes place. However, this may also occur in other chambers of the engine, for instance within the crankcase of a two-cycle engine. In this connection it should be emphasised that the walls which enclose the combustion chamber need not be identical after completion of one working cycle. For instance, a two-cycle engine controlled by a rotary valve rotating at one-third of the crank speed will not complete its cycle before three complete revolutions of the crankshaft. Such engines have been designed and built. Although after completion of a working cycle one part of the combustion chamber is formed by a different surface area of the rotating valve, this engine is a one-cylinder, two-cycle type.

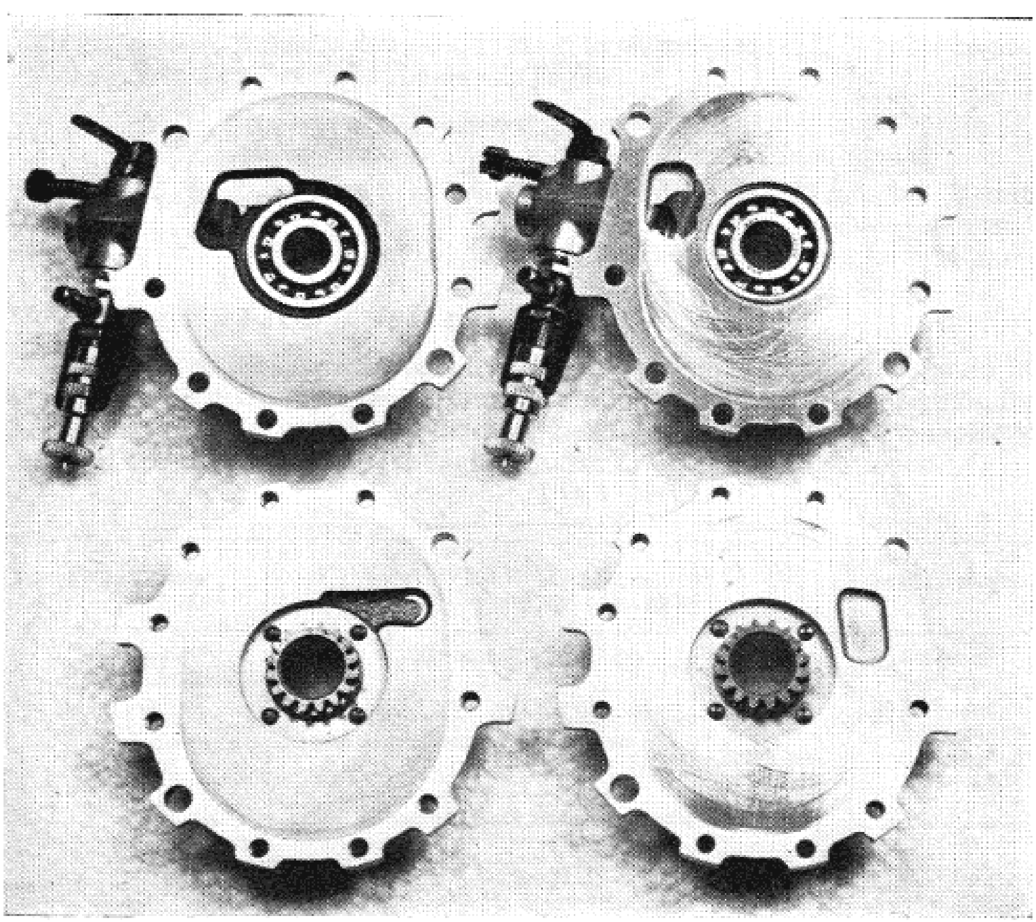
The NSU-Wankel engine has two additional chambers in which auxiliary strokes are occurring. The deciding expansion stroke does always take place in the same position of the housing at the corresponding phase of the rotor.

The four-cycle engine requires two complete revolutions of the crank-shaft to be ready for a new torque impulse.

The two-cycle engine requires only one revolution. The rotating combustion engine is likewise ready for the following power impulse after one revolution of its shaft. Therefore it is completely comparable to a one-cylinder, two-cycle engine.



Below: The front and rear plates of the 1970/71 model O.S. Wankel motor (left) compared to those of the latest 1971/72 version. Note re-shaped induction ports.



4. *Two-cycle engine and rotating combustion engine*

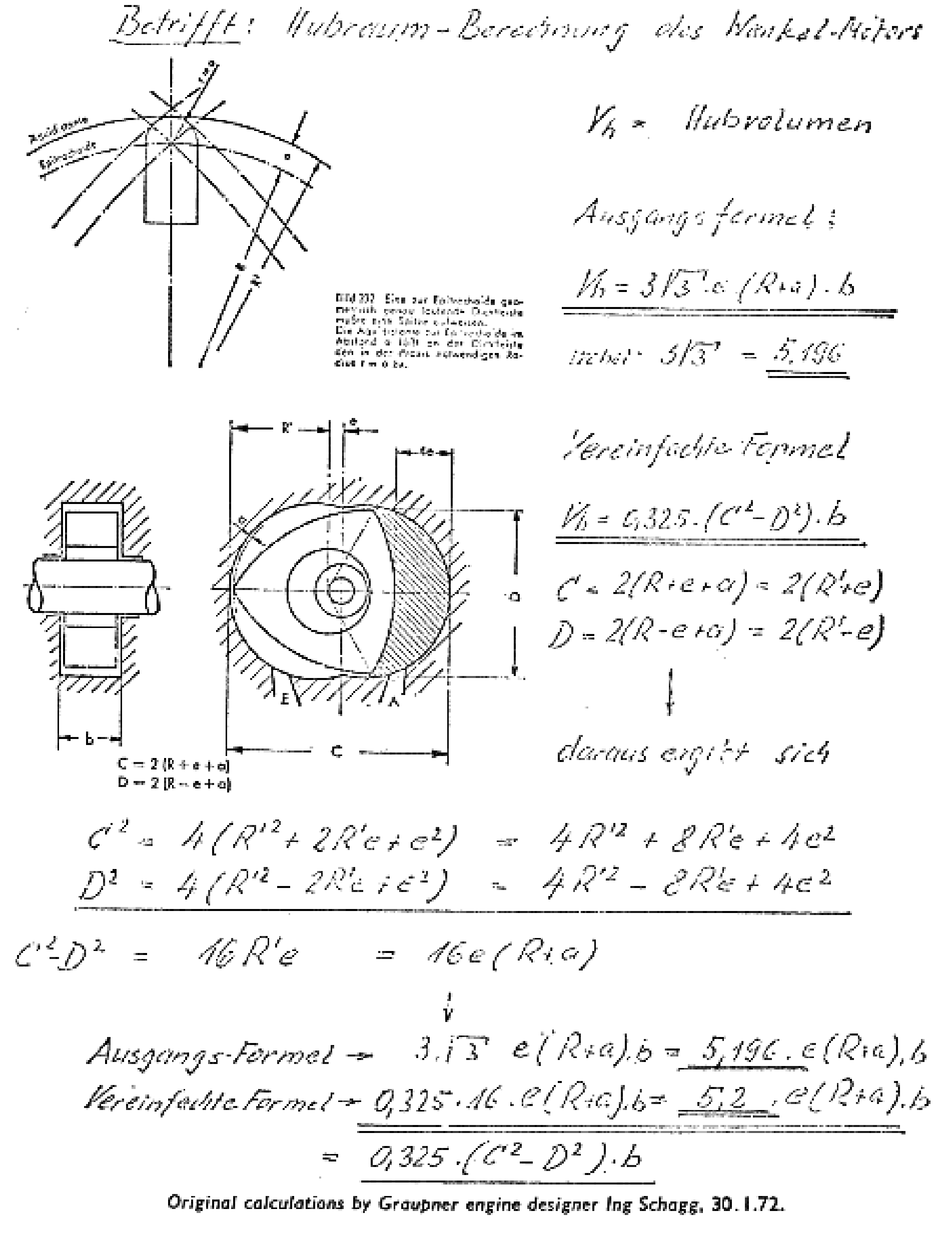
This identity can be seen from the formula defining the power, which for both engines is the same:

$$N = \frac{i \cdot V_z \cdot p_e \cdot n}{60 \cdot 75} \quad [HP]$$

It must be emphasised that a rotating combustion engine will perform at no higher output than a two-cycle engine which reaches the same volumetric and thermal efficiency.

5. *Torque diagram*

The torque diagram showing the effective torque on the power-take-off shaft is a deciding criterion for classification of a piston engine. The shape



Original calculations by Graupner engine designer Ing Schagg, 30.1.72.

shown in *Fig.* 2 makes it clear that the NSU-Wankel is equivalent to a one-cylinder, two-cycle engine.

It is irrelevant that the expansion stroke spreads over 270° of the crankshaft, while in a two-cycle engine it takes only 180°. Starting with identical indicator diagrams the torque areas are identical too; that means both engines show the same output.

6. *Definition of the rotating combustion engine as a three-cylinder unit*

As emphasised before, there is no reason to consider the rotating combustion engine to be a three-cylinder unit as far as the design and operation is concerned. If it would be a three-chamber engine the formula for the output would look as follows:

$$N = \frac{3 \cdot i \cdot V_K \cdot p_e \cdot \frac{n}{3}}{60 \cdot 75} \quad [HP]$$

Hereby a speed $\frac{n}{3}$ shows up, which actually does not exist in the engine.

The rotor is transferring the gas power to the shaft without absorbing any torque itself.

The only part of the engine which is affected by a torque is the eccentric shaft. Therefore only the speed of this shaft provides a basis for calculating the output.

Summary

The formula for the output of a two-cycle engine and the torque definition fully correspond. Actually there is no reason to valuate the NSU-Wankel engine different from a one-cylinder, two-cycle engine.

Examples:

Reciprocating Engine

D = 24 mm, S = 22 mm.

$$\text{Piston area} = \frac{D^2\pi}{4} = 4{\cdot}52\ \text{cm}^2$$

$Vh = 4{\cdot}52\ \text{cm}^2 \times 2{\cdot}2\ \text{cm} = 9{\cdot}944\ \text{cm}^3$

Rotary Piston Engine

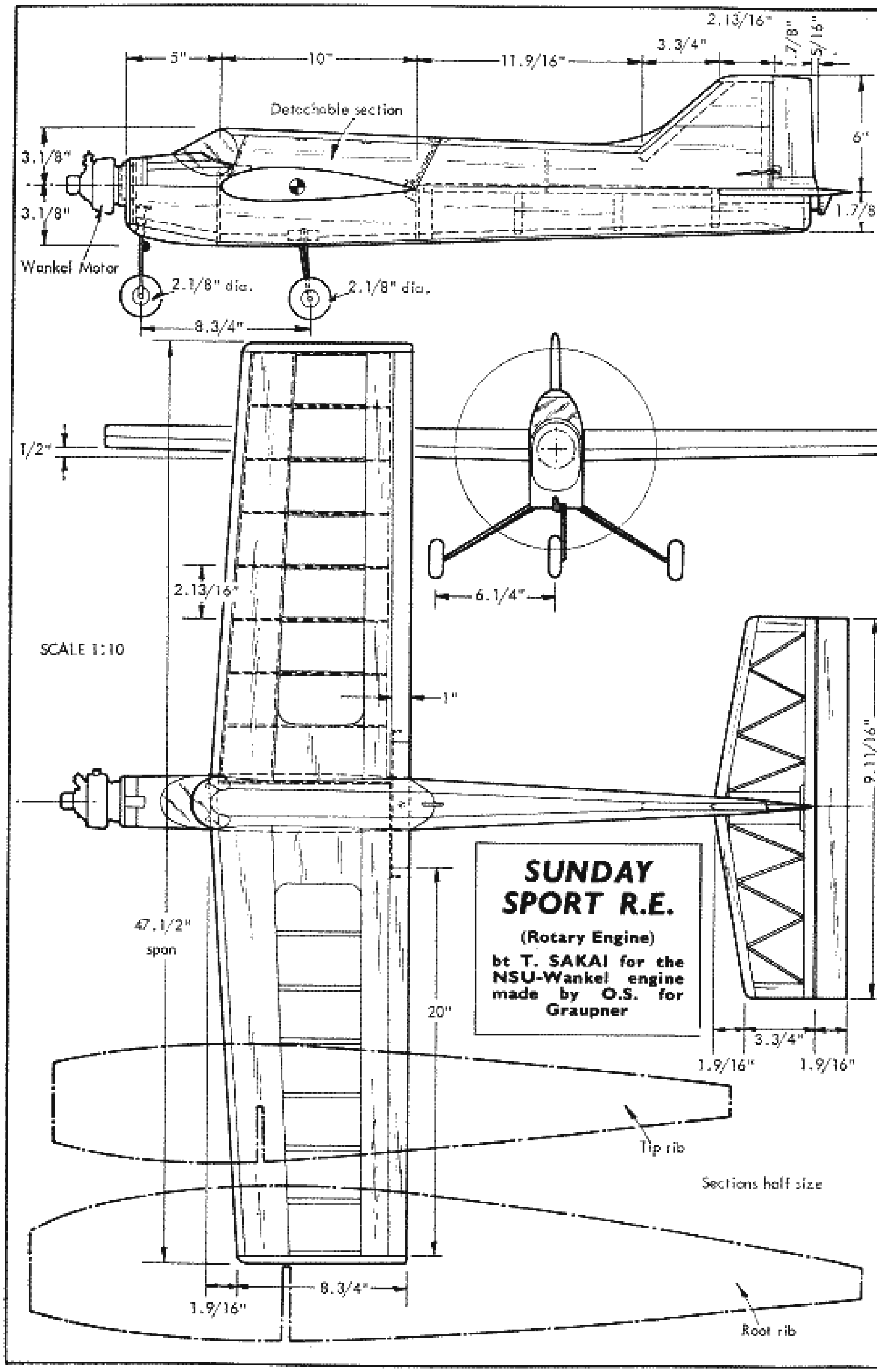
C = 58 mm, D = 43 mm, b = 20 mm

Stroke area $\cdot 325(C^2 - D^2) = 4{\cdot}92\ \text{cm}^2$

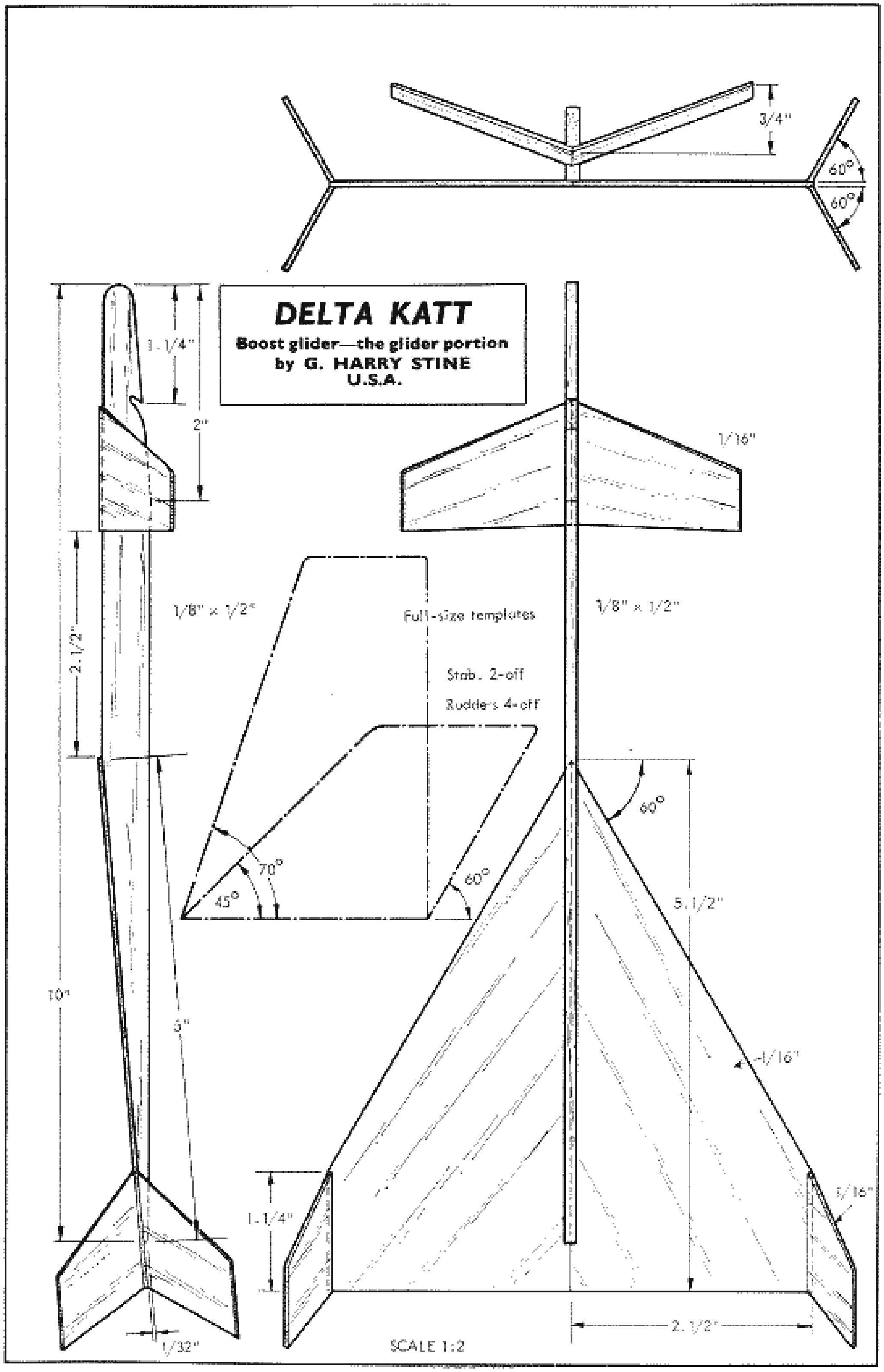
$Vh = 4{\cdot}92\ \text{cm}^2 \times 2\ \text{cm} = 9{\cdot}84\ \text{cm}^3$

Manufacturer's specifications, once checked by a neutral institution, should be accepted as a guarantee for the uniform dimensions of all production engines, for a change in piston diameter or trochoid dimensions would result in a completely different engine type due to the high manufacturing standards involved.

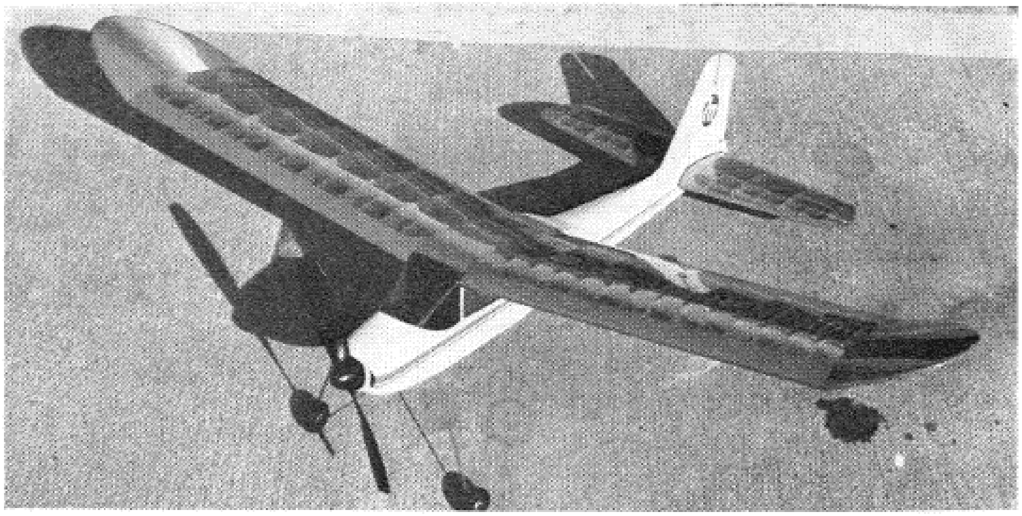
Manufacturer	*C*	*D*	*Stroke Area* $0{\cdot}325\ (C^2-D^2)$	*b*	*Swept Volume*
J. Graupner, Kirchheim/Teck	50 mm	38 mm	3,432 cm²	18·7 mm	6·42 cm³
	,,	,,	,,	16·0 mm	5·49 cm³
	,,	,,	,,	15·0 mm	5·15 cm³
	,,	,,	,,	14·5 mm	4·98 cm³
	,,	,,	,,	12·0 mm	4·12 cm³
	,,	,,	,,	10·0 mm	3·43 cm³



5"
10"
11.9/16"
3.3/4"
2.13/16"
1.7/8"
5/16"
Detachable section
6"
3.1/8"
3.1/8"
1.7/8"
Wankel Motor
2.1/8" dia.
2.1/8" dia.
8.3/4"
1/2"
6.1/4"
2.13/16"
SCALE 1:10
1"
9.11/16"
47.1/2" span
20"
SUNDAY SPORT R.E.
(Rotary Engine)
bt T. SAKAI for the NSU-Wankel engine made by O.S. for Graupner
3.3/4"
1.9/16"
1.9/16"
Tip rib
Sections half size
1.9/16"
8.3/4"
Root rib



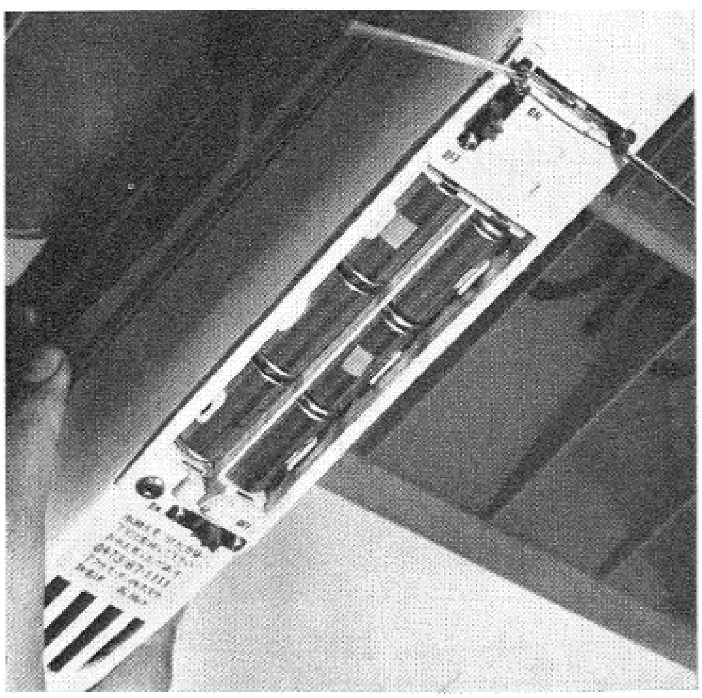
MODEL ROCKETRY USA



ELECTRIC POWER FOR RADIO CONTROL

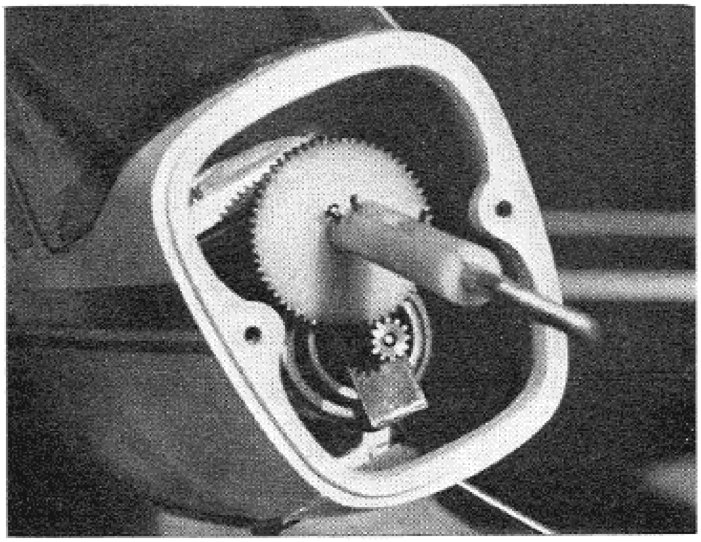
by M. Masuda

BACK twelve years ago, in the 1960/61 *Annual*, your compiler, Ron Moulton, closed a summary on electric power experiments with a forecast that the ready moulded electric model with clip-in batteries would be in great demand. Fred Militky's pioneering with his **Graupner** "*Silentius*" led to a second feature in the 1962/63 *Annual* where Ron Moulton discussed the water-activated cell as a weight-saving possibility for the electrical power source. Meanwhile there have been other experiments. Notable was the achievement by Roland Boucher of California with his large *Fournier RF*4 scale model which has flown for con-



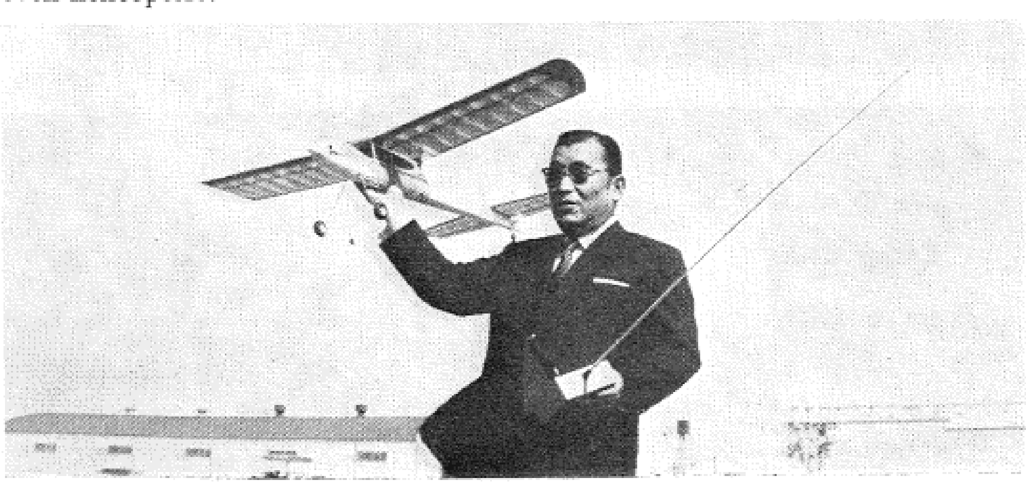
Top: The Mabuchi model. Wing and tail surfaces are of conventional balsa structure, covered with a translucent polyester film. The fuselage is a built-up prototype for what is obviously intended to be a plastic moulded product when the whole project is prepared for mass distribution. At left is the bank of six 1·2 volt rapid re-charge nickel cadmium type cells. Each is smaller than a standard pen-cell. Re-charge time is only 4 minutes. One switch is for propulsion motors, the other is for the radio control circuit. Note the "If lost . . ." notice in Japanese. Span 37½ in., length 28 in., weight 19 oz., area 260 sq. in., loading 11 oz./sq. ft.

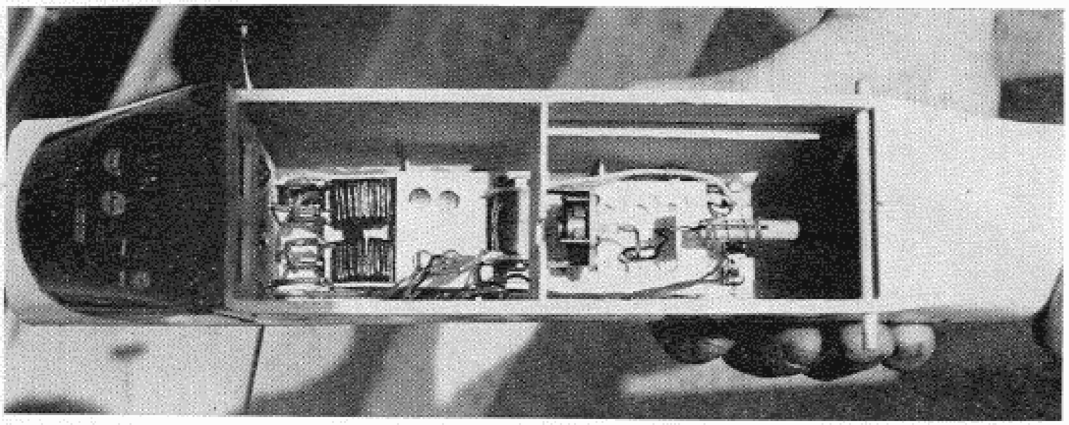
With nose cowl and its front bearing for the extension shaft removed, the Mabuchi electric motor is revealed with its reduction gears. The motor is designed to operate at 10,000 r.p.m., with propeller speed of 4,500 r.p.m. Propeller diameter is just under 9 in. and the pitch $6\frac{1}{2}$ in. Below: Mr. Ken-ichi Mabuchi, President of the Japanese company which has made millions of electric motors annually for the toy and hobby trade, with the prototype on which a Kraft digital proportional radio control outfit is installed with two servos, for rudder and elevator. This model is not exactly the same as the one in heading opposite. Note difference in tip dihedral.

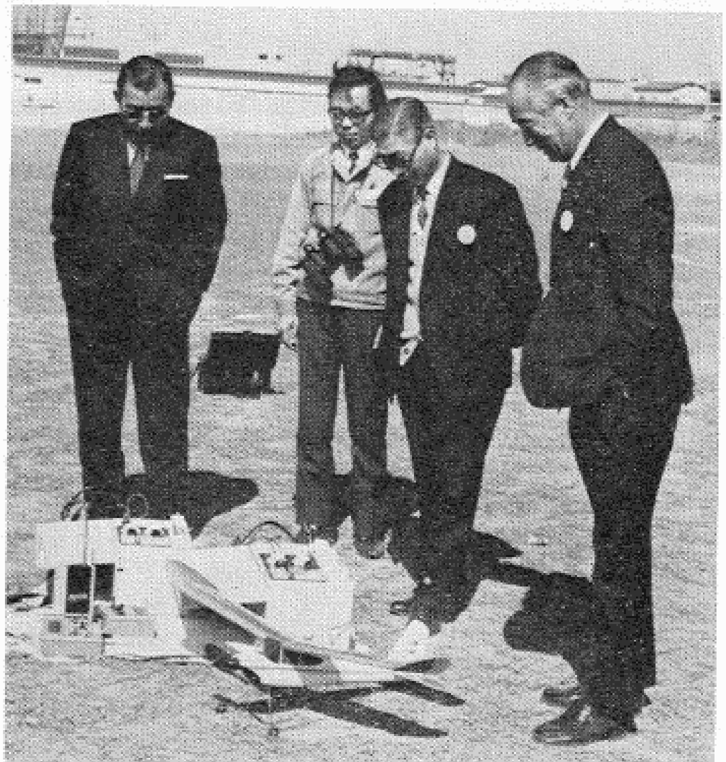


siderable distances. Electric powered radio controlled models have been successfully flown by many individual experimenters but not until 1972 did the project become something for everyman. The **Mattel** Company launched an electric powered ready to fly model with a **Mabuchi** power unit after their work on the rapid re-charge "*Sizzler*" model car. This model has yet to reach Europe in numbers as we write; but R/C variations have been flown in the U.S.A. What they have done is to overcome the two serious snags of electric power, namely (1) power to weight ratio, and (2) economics and convenience of operation.

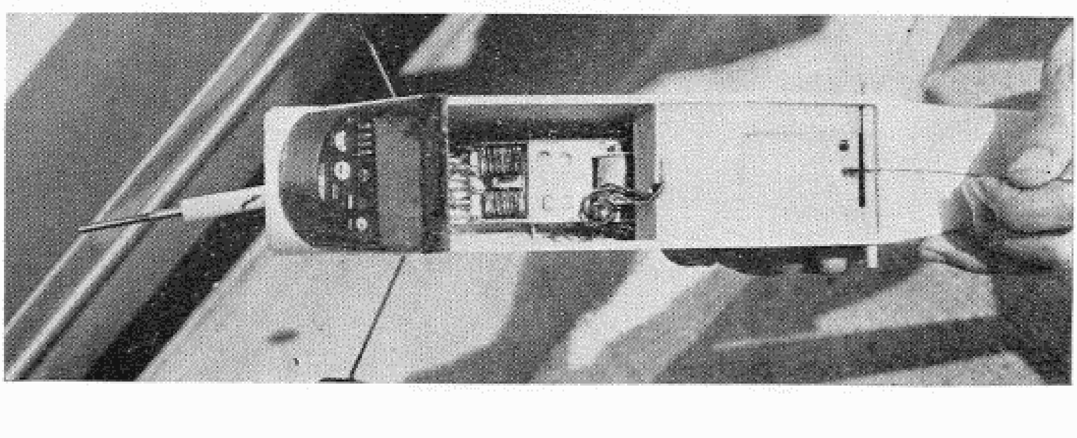
In the first instance, it is the phenomenal output of the little Mabuchi units which were modified for slot car racing that has led to excellent power to weight ratios in the motors themselves. The motor in the model seen on these pages is said to be equal to a ·09 (1·5 c.c.) internal combustion engine! The rapid re-charge cells, which have also become possible over the last year or so, improve the power factor considerably and at the same time make the whole proposition practical. Now one can re-charge from a car battery through the cigarette lighter socket! The Mattel unit re-charges from a lantern dry cell. What we show here is a glimpse into the future. Consider the size and weight of models which are flying most successfully in 1972 and think of control-line, boats, powered gliders, even helicopters.

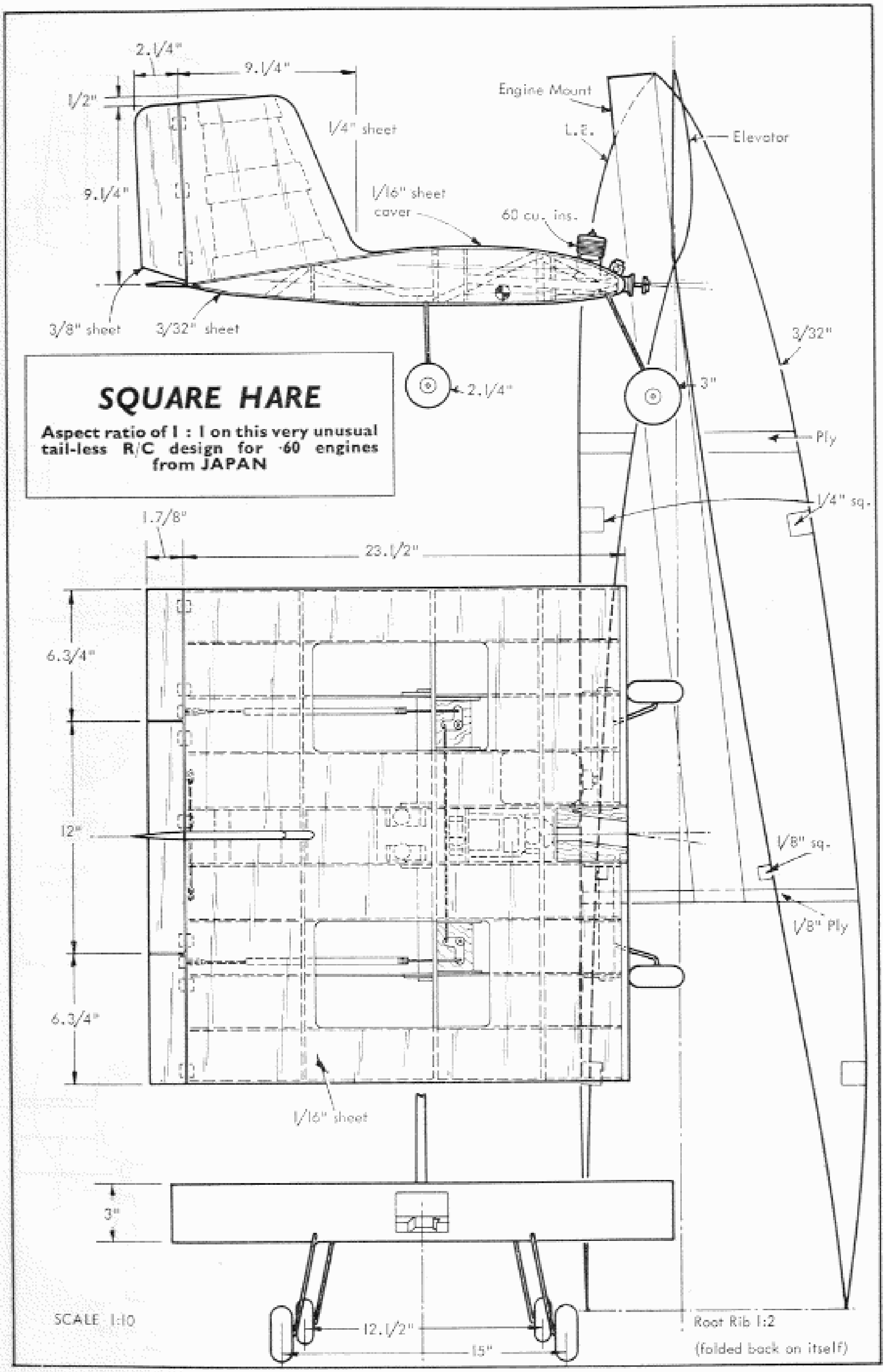






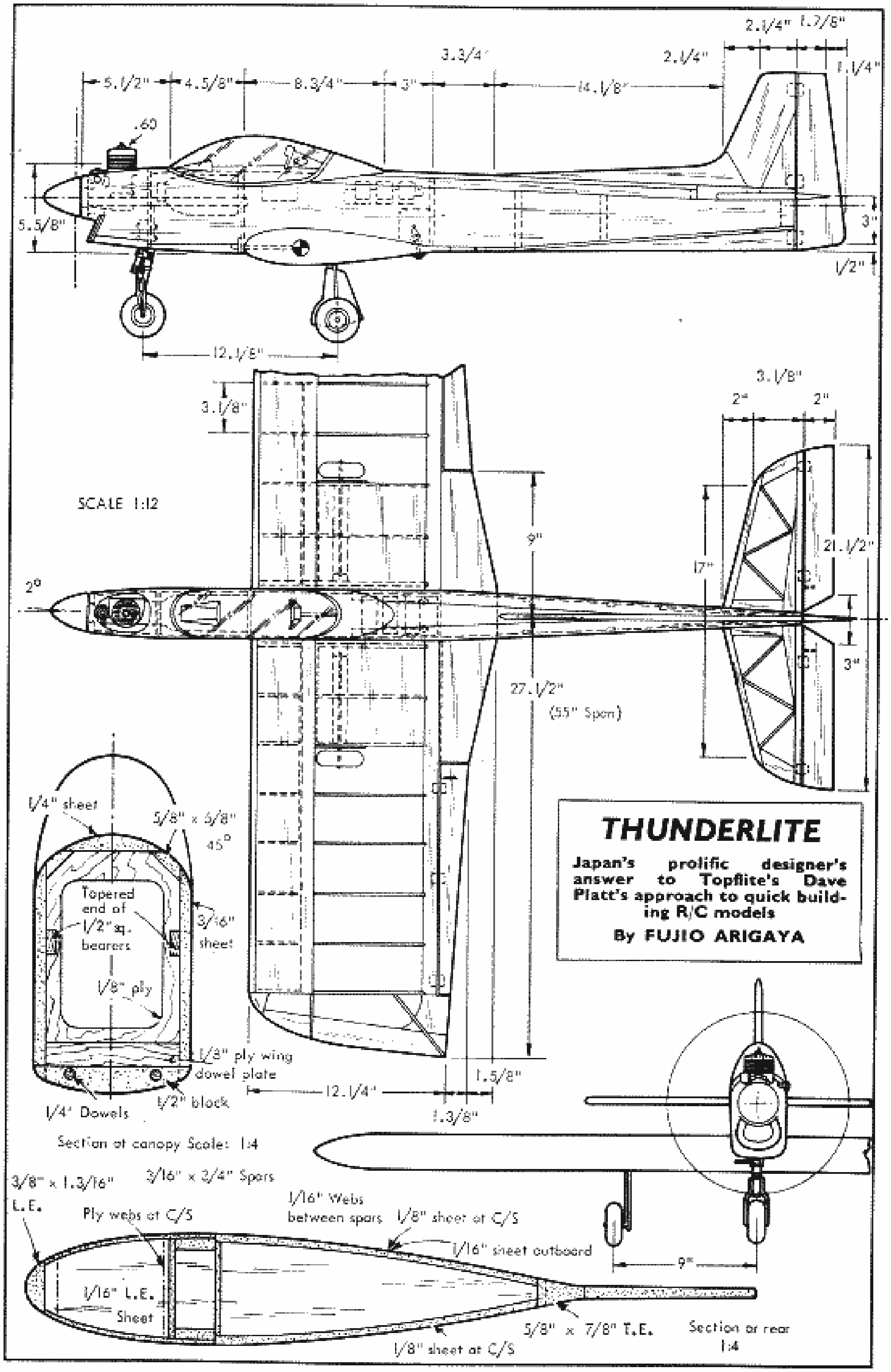
Above: A view inside the fuselage shows the two large resistors, which are probably in the battery circuit for propulsion, and a magnetic actuator which operates the rudder by rocking the torque rod, a wooden dowel seen entering the rear fuselage. The magnetic actuator is the lightest form of proportional control, having the disadvantage that the rudder is continuously "hunting" from side to side, but it biased according to control, in one direction or the other. In the view below, the receiver has been added above the activator and is held in place with foam plastic. At left left to right : Ken-ichi Mabuchi, a Mabuchi mechanic, M. Masuda and Takeo Isobe of "R/C Technique", wait while batteries are re-charged for more flying.





SQUARE HARE

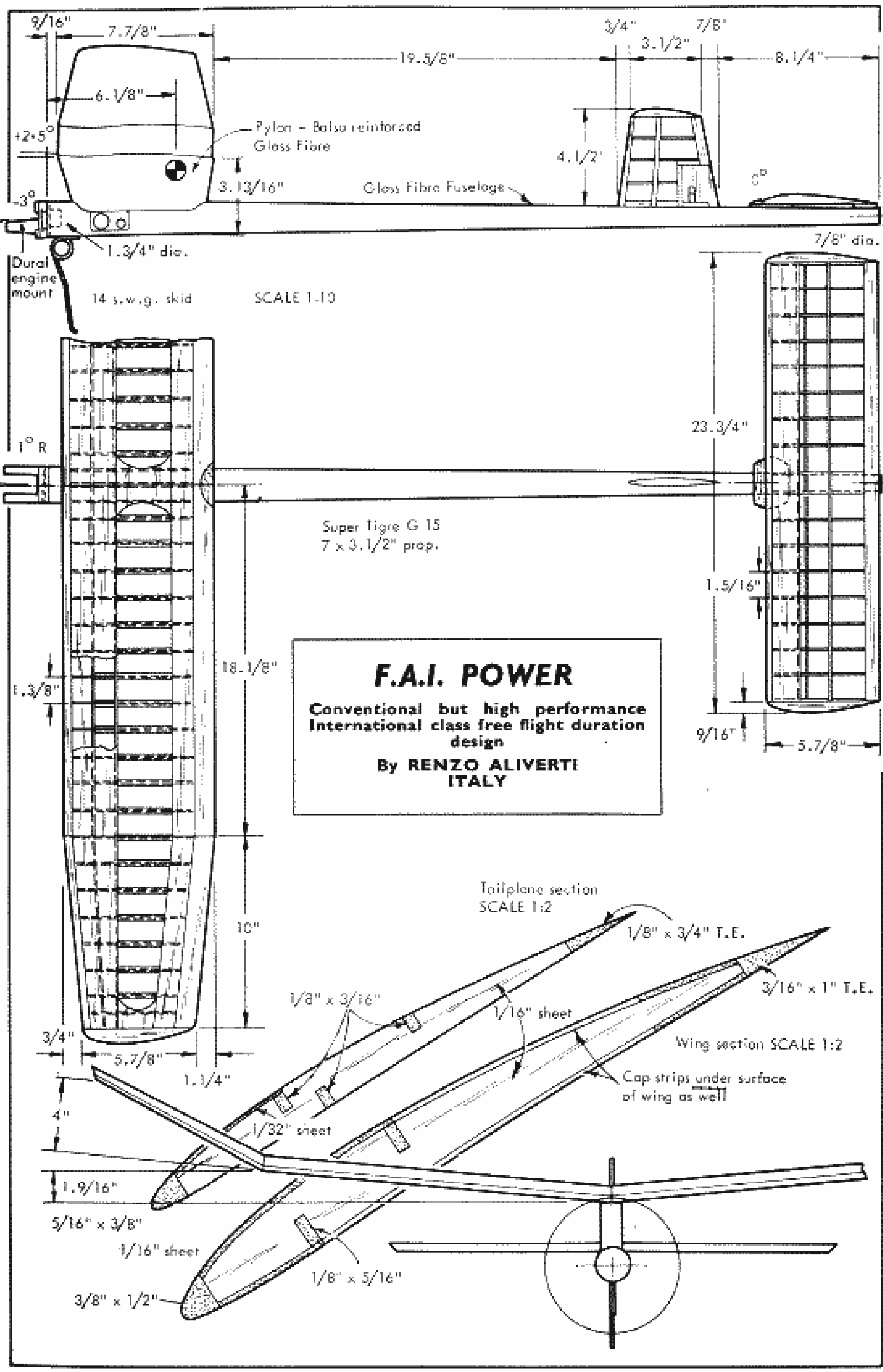
Aspect ratio of 1 : 1 on this very unusual tail-less R/C design for ·60 engines from JAPAN



THUNDERLITE

Japan's prolific designer's answer to Topflite's Dave Platt's approach to quick building R/C models

By FUJIO ARIGAYA

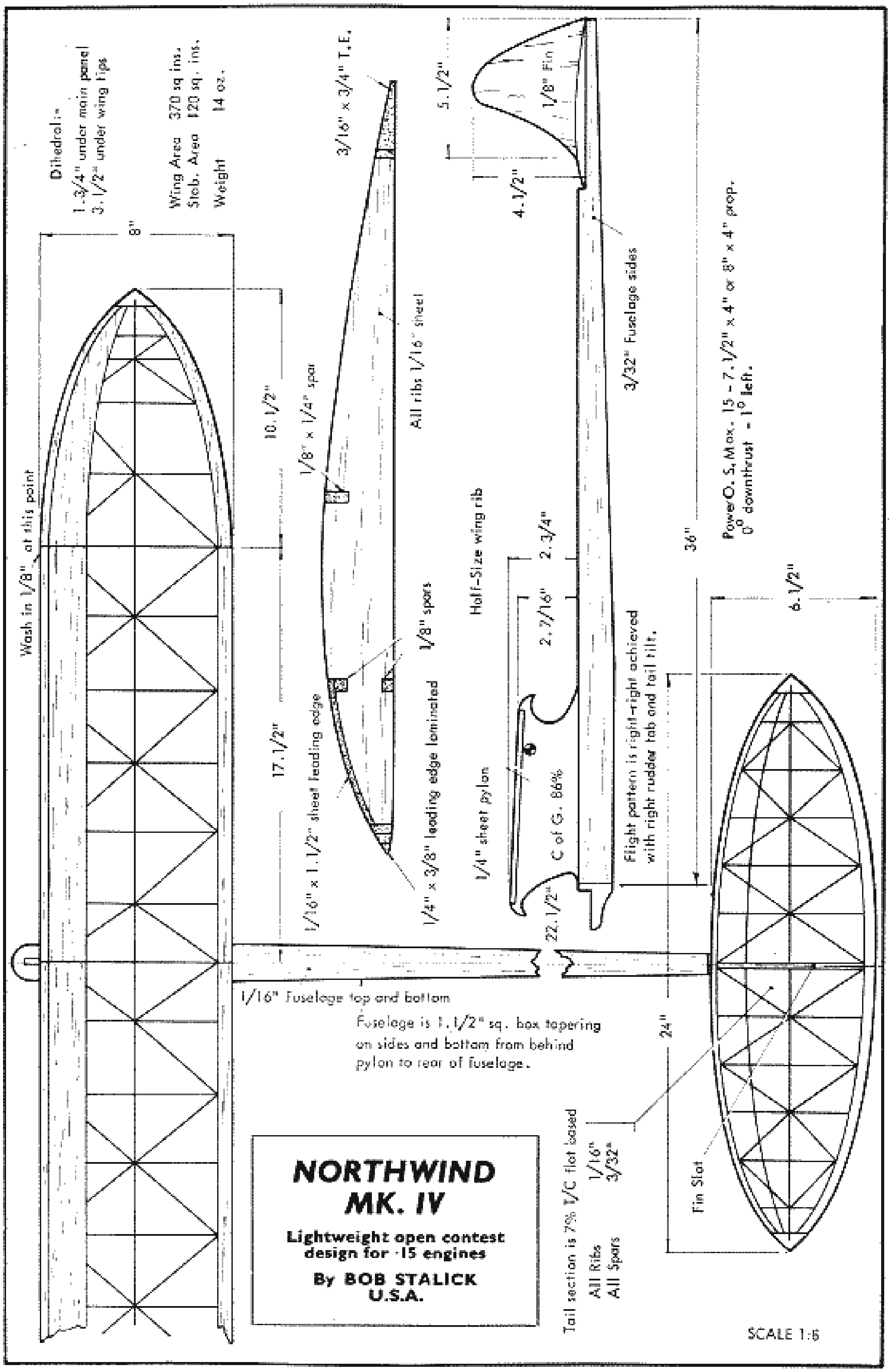


F.A.I. POWER

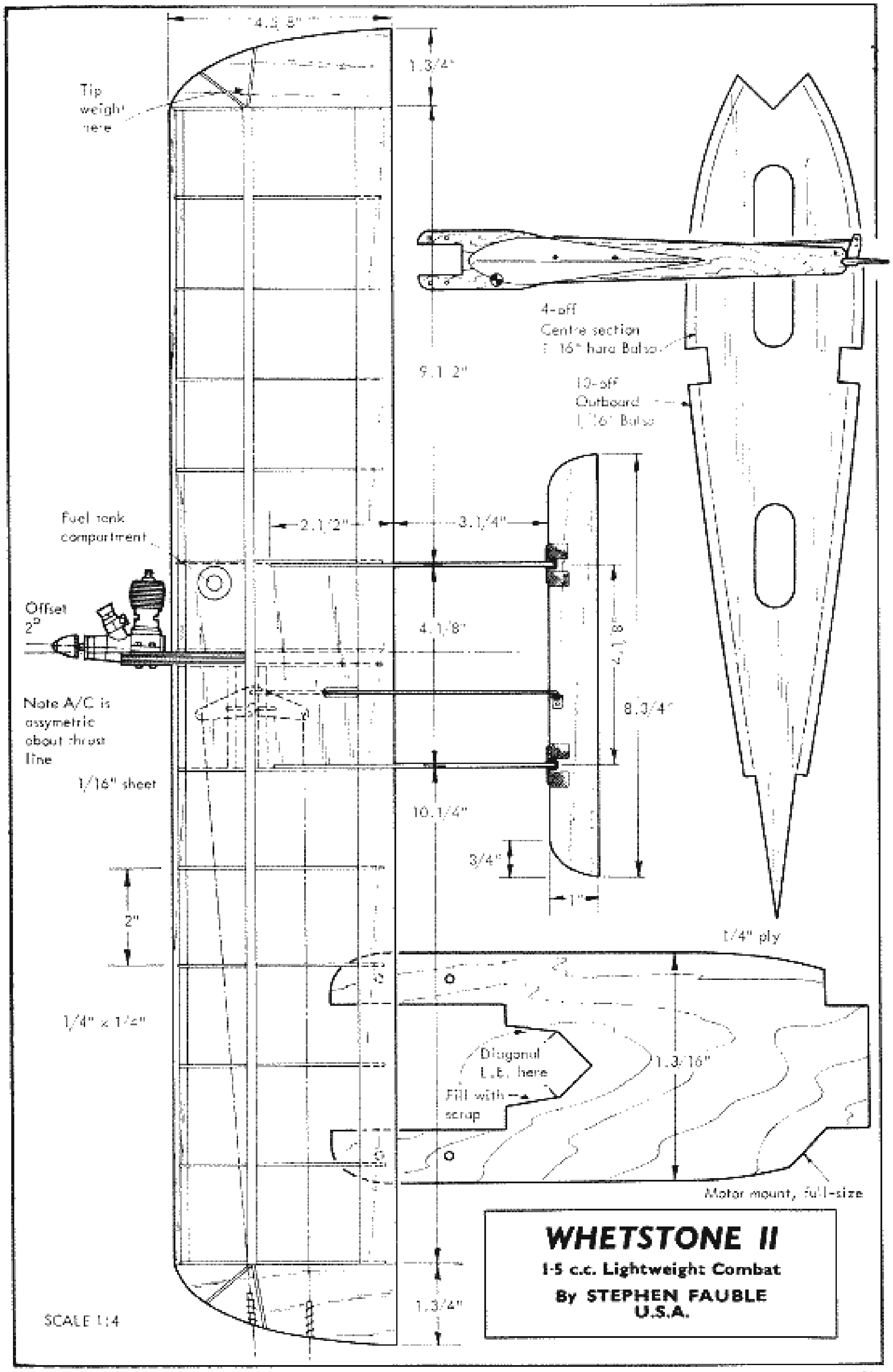
Conventional but high performance International class free flight duration design

By RENZO ALIVERTI ITALY

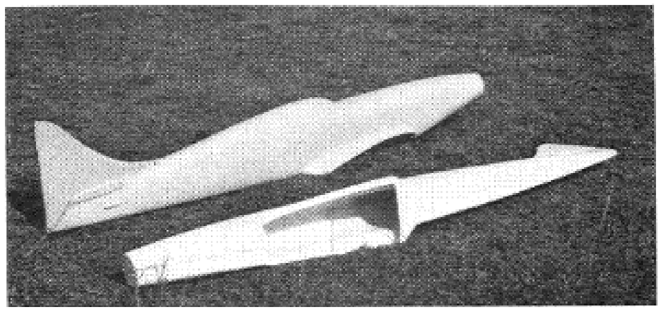
MODELLI



WILLAMETTE PATTER



MODEL BUILDER USA



MAKING POLYESTER PLASTIC FUSELAGES

by Pham Anh Tuan

THE modellers who are prepared to make their own polyester fuselages know the type of aircraft they want to build, so we will assume they can carve the master and cast the female mould. We must now consider the question of actual lay-up of the fuselage.

The aim of this article is to give readers as many hints as possible to enable them to go ahead without further undue difficulty.

Moulds are made of the same material as the fuselage, *i.e.*

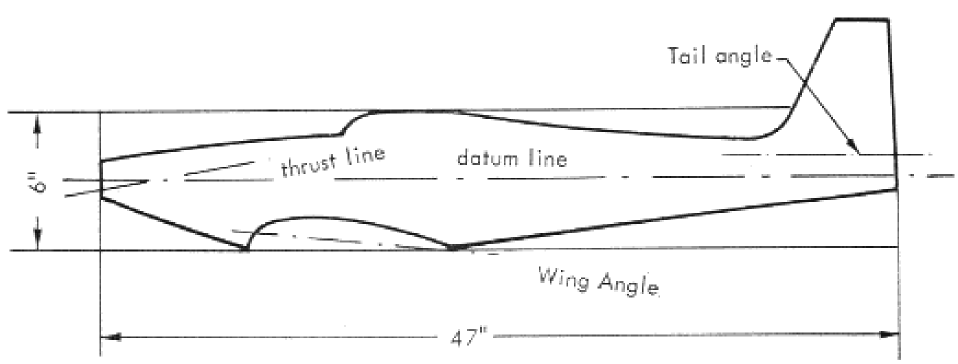
1. a base resin,
2. the gel coat,
3. the release agent,
4. the glassfibre (medium weave: about one mm).

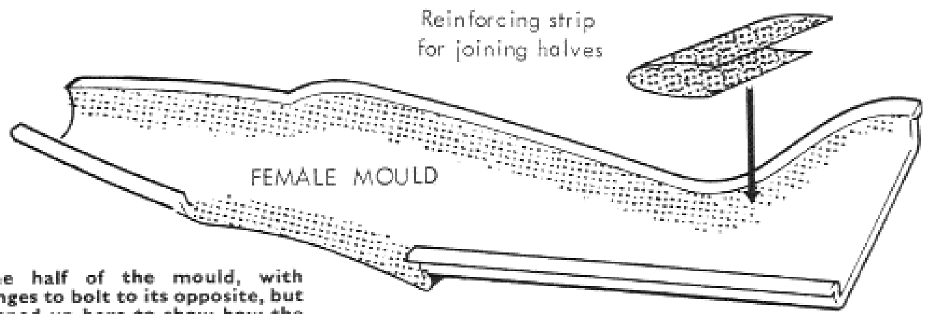
The fuselage should be built in a well-aired room. A workshop is the most suitable, but if one is not available, use a room with large windows which can be opened fully.

The principle of construction is as follows:

The fuselage mould is in two halves. The two halves are joined together with bolts, and a band of glassfibre matting is used to reinforce the seam.

The object is to put a smooth piece of cloth (or mat) over the release agent inside the two halves of the mould. First spread the release agent generously over the joint area, making sure the surface is covered with release agent and that no excess builds up inside the mould. Leave it to dry for at least one hour. The release agent must be completely dry.





One half of the mould, with flanges to bolt to its opposite, but opened up here to show how the reinforcing strip is fitted.

After this, prepare a dose of gel coat and add to this the catalyst. Using a paint brush, apply an even coat of gel over the dry release agent. Too thick a layer of gel coat will impair the solidity of the fuselage.

Leave it to dry for about half an hour, until the gel coat is tacky. While waiting, cut the glassfibre into two pieces sufficient to cover each of the insides of the moulds, leaving a few inches for overlap.

The glassfibre is then applied to the gel coat in the two halves of the mould. Gently rub the glassfibre to ensure perfect adhesion to the gel coat; this will determine the final finish of the fuselage.

Now, prepare a larger quantity of base resin, adding less catalyst.

Using a paint brush, spread the base resin evenly over the glassfibre, paying particular attention to the seam (make sure the glassfibre does not bubble at this place), and other areas such as the wing supporting flairs, fin leading edge, etc.

Reinforce the glassfibre in those places which are more susceptible to damage, *i.e.*, the nose of the fuselage, the wing supporting fairings and the fin, etc.

Have a sharp knife at hand.

When the resin has almost set (when it is firm) cut away the excess glassfibre.

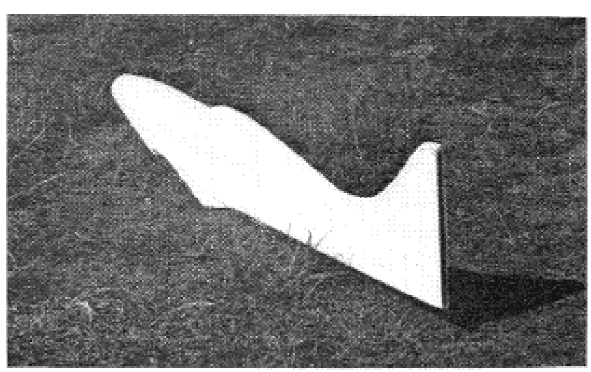
The two halves of the fuselage, though stuck together in the moulds, are now ready.

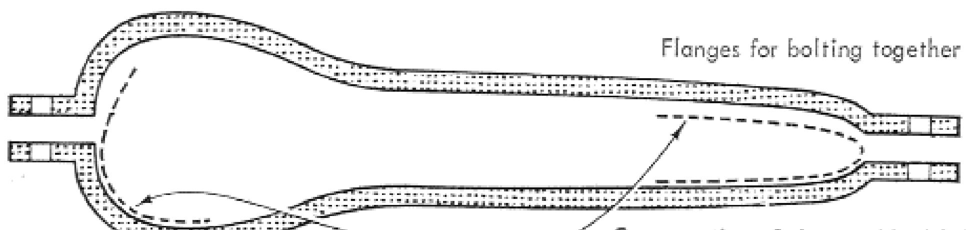
Now, the two halves must be joined securely.

We have already said it is very difficult to make a clean join at the fin without taking special precautions.

Cut bands of glassfibre approximately one and a half inches wide; these are for the seams.

Elegant shape of this radio controlled model fuselage, made by Pham Anh Tuan of Paris, shows exactly what can be done once one acquires the "know-how" on epoxy forming. Heading opposite displays twins from the same mould, with the large aperture left for the wing root to give access for laying up the glassfibre in the mould.





Cross section of the mould with flanges split apart for clarity. The strips are edged into place over the mat or glass cloth which has been laid inside the sealed mould. It is best to do all the work within the moulds even though access is difficult, early removal being prone to distortion or curving.

Cut a small band of glassfibre for the tail fin leading edge. Dip the band in base resin, put it on one side of the tail fin and curve it along the leading edge.

Do the same with the other inaccessible parts, *i.e.*, the inside of the fuselage near the tail fin.

Work through the apertures left at the base of the fuselage for the wing, and at the rear of the fin, using sticks as spatulas and a long-handled paint brush. The glassfibre band must be moved into position while the resin is still fluid.

With the two halves assembled, the job is now three-quarters completed.

All that remains to be done is to apply the glassfibre strip to the other seams.

This is a difficult operation due to the lack of access. The band must be rolled up, soaked in resin, placed on the accessible part of the seam, and unrolled with the aid of a long and curved spatula.

The second "trick" is to put the resin impregnated strip on to a piece of balsa, slide this into the fuselage and turn it *upside down* so that the strip drops onto the seam.

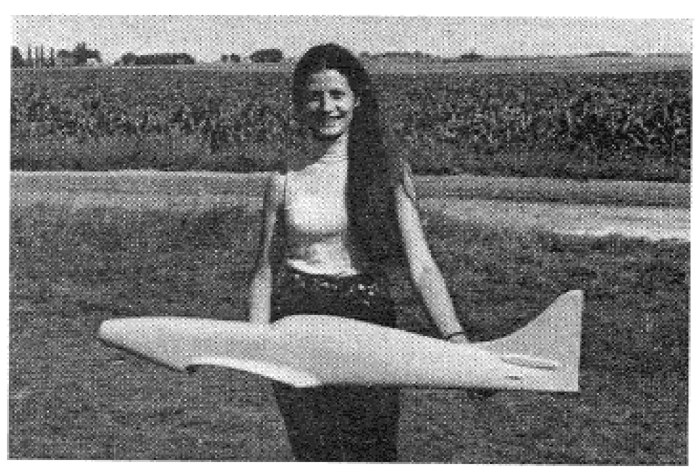
Once this strip is in position, cut off any excess material.

Leave the fuselage for several hours so that the resin is perfectly dry before taking away the moulds.

Unscrew the mould retaining bolts.

With the aid of a screwdriver, gently prise the two halves of the mould apart, paying careful attention not to damage the joining surfaces of the moulds.

Gently press away any excess glassfibre along the seam of the fuselage, then wash off the release agent with water.



Two fine fuselages here! Note the integral fairings for the wing seating and tailplane, and the ready prepared outlet for the rudder push rod.

You now have a glassfibre fuselage.

The back of the fin should be blocked with a piece of balsa and fixed with resin. This will provide a firm mount for fixing hinges.

On the inside of the fuselage, cross ply the matting to aid strength

One might imagine a great deal of work being involved in all this. In fact, the opposite is true!

Once the formers and engine mount are installed, the rest is easy.

Bearing in mind the precision of the mould, the formers can be cut and pierced beforehand—this is, of course, a great advantage.

The fuselage should be rubbed down with a fine wet abrasive material (grade 400) before being painted with Epoxy.

With a little experience, it is possible to build a fuselage in one evening. Cost is relatively little.

With this type of material it is possible to build models weighing less than 6½ lbs, quite suitable for competition flying.

The two main advantages, therefore, are speed and cheapness, and also versatility of fuselages thus made. Rounded curves, aerodynamic forms, wing supporting flairs, etc., are difficult to realise when using only balsa for construction.

Many people decry the use of polyester plastics for fuselages. They say that this type of material gives rise to vibration and interferes with the radio equipment.

We do not agree with their views. Vibration has never given any trouble.

During many months of flying the author had no trouble at all. The servos were simply stuck to the side of the fuselage on rubber mounts. Reasoning is quite simple—the sides are fairly resilient and quite elastic in themselves.

Gliders, Control-Line and other types

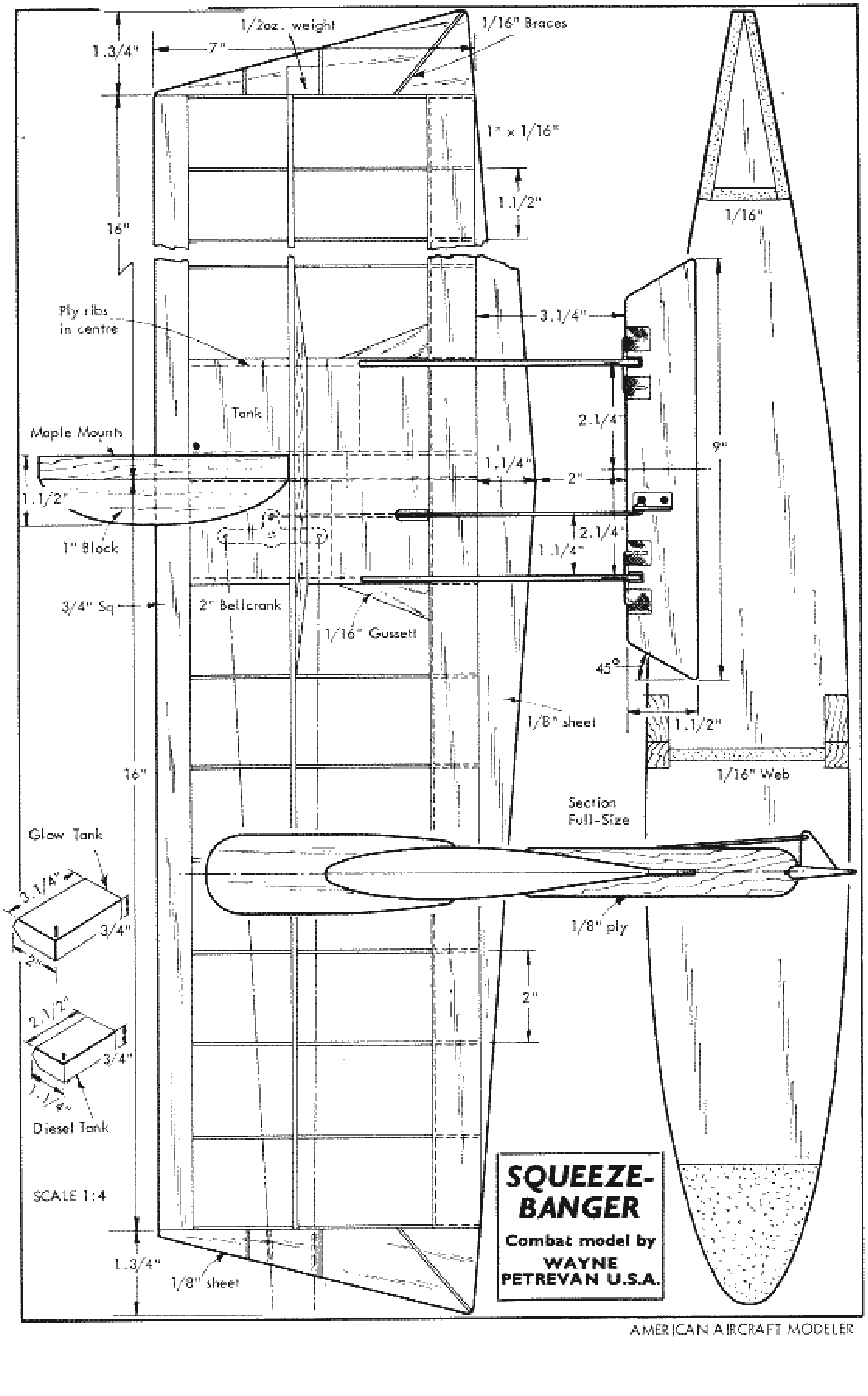
Although the text has so far dealt exclusively with a radio controlled subject, application of the same method could produce fuselages for other types ranging from team racers to slope soaring gliders. In fact, the control line models have a lot in common with the radio example except that they are in general smaller. For some subjects it will be necessary to add extra reinforcement, around the nose of a glider for example, and also to prepare for removable hatches which will have to be cut away.

As a club project, the polyester fuselage has a lot to commend it. Shared cost of the original carved or plaster shaped master, and the preparation of the moulds, will result in production line procedures which bring satisfaction to a whole group of clubsters. Moreover, it introduces a club "shape" of model—a uniformity that some people like to adopt for identification on the field.

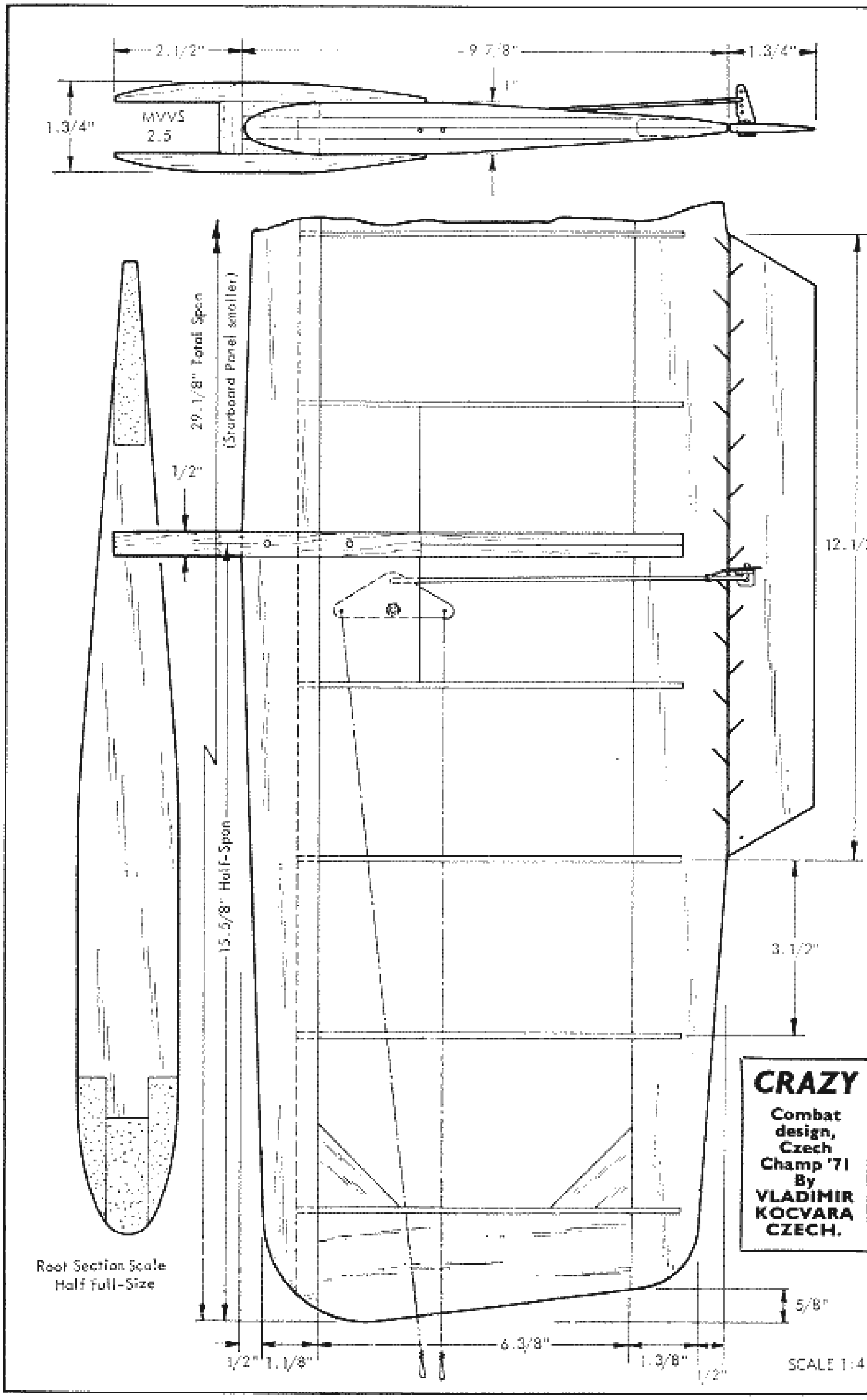
Material Suppliers

Supply of materials is fairly easy to locate. There are specialist companies who have long been loyal to the modelling movement for example,, *Bondaglass* and *Format*. The latter, at Northbrook Avenue, St. Giles Hill, Winchester, have produced special kit sets and can offer a vast range of epoxy materials. In fact it was after a visit to Format's original workshops that the author of this article felt qualified to write and give his knowledge to others who might otherwise have been mystified by the very term "polyester plastic".

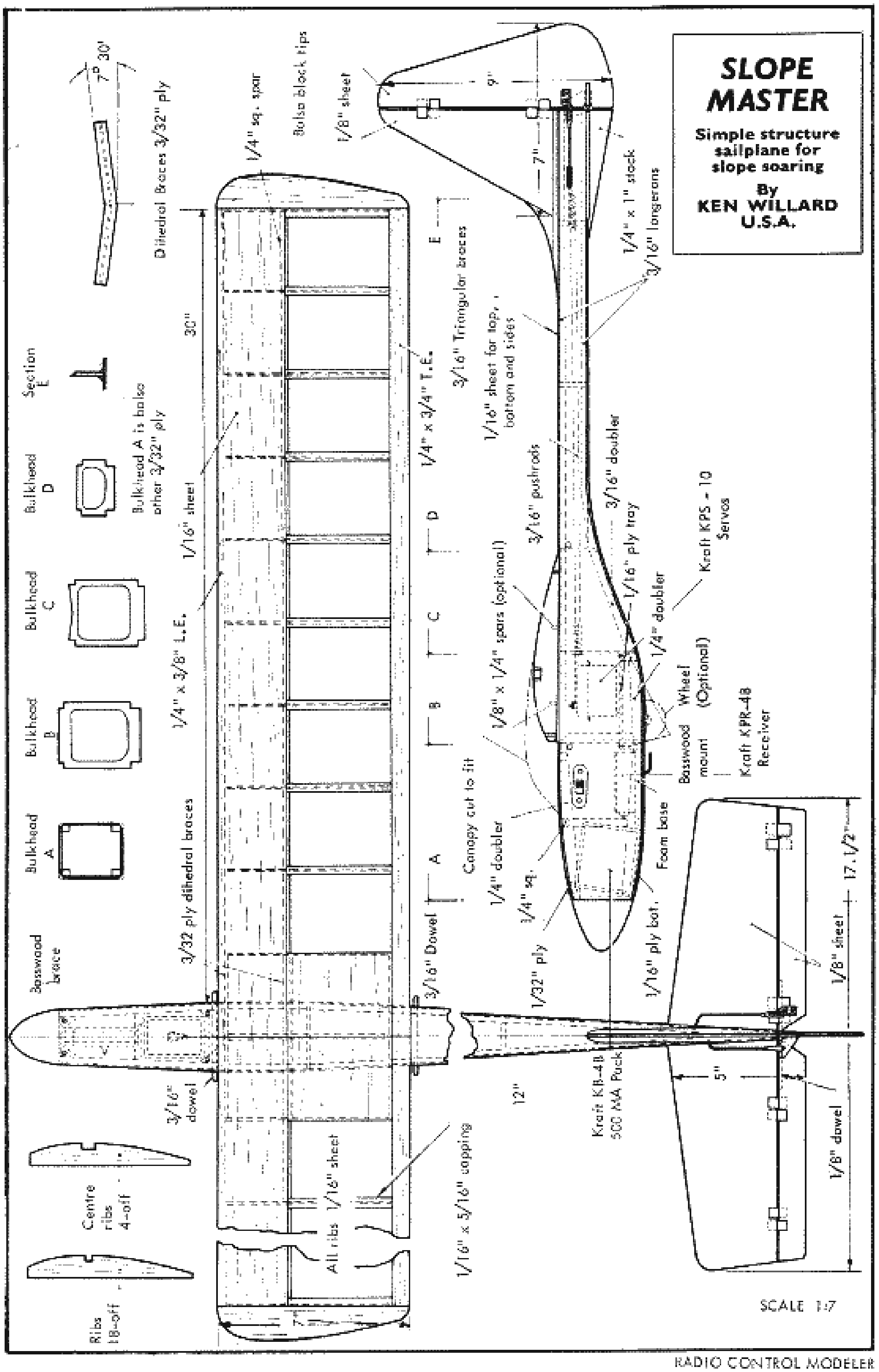
Try it—you'll like it!



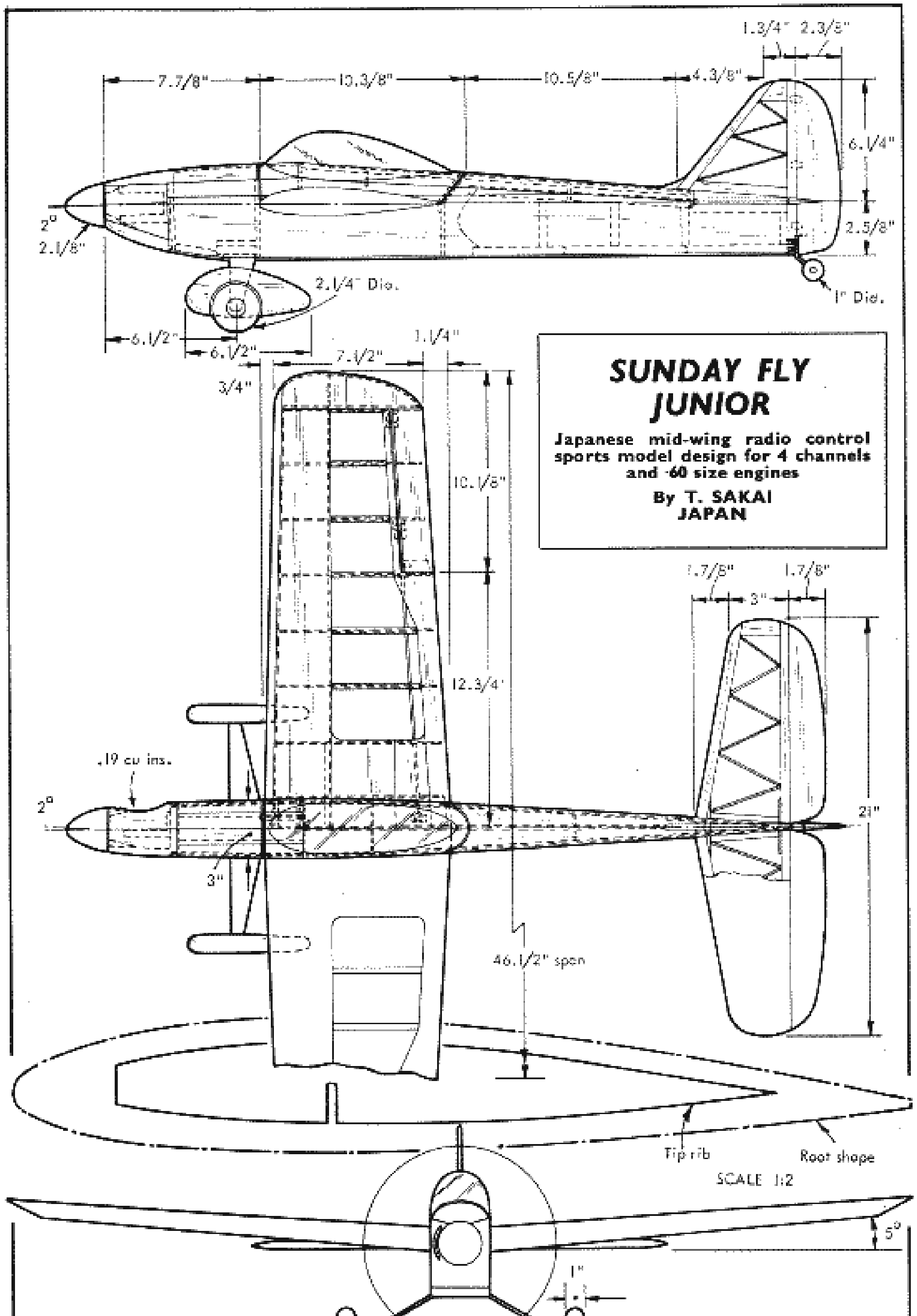
AMERICAN AIRCRAFT MODELER



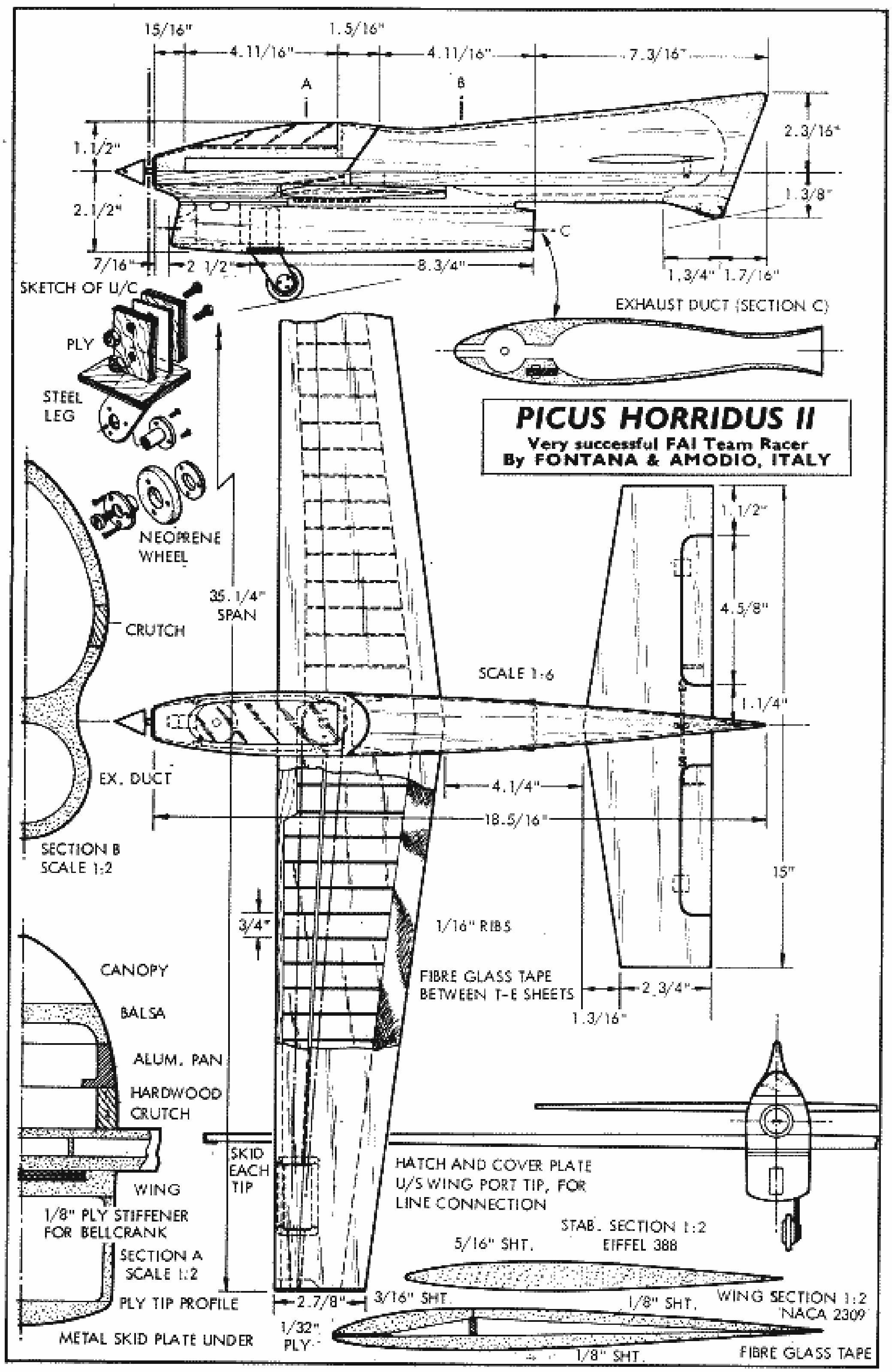
MODELAR - CZECH



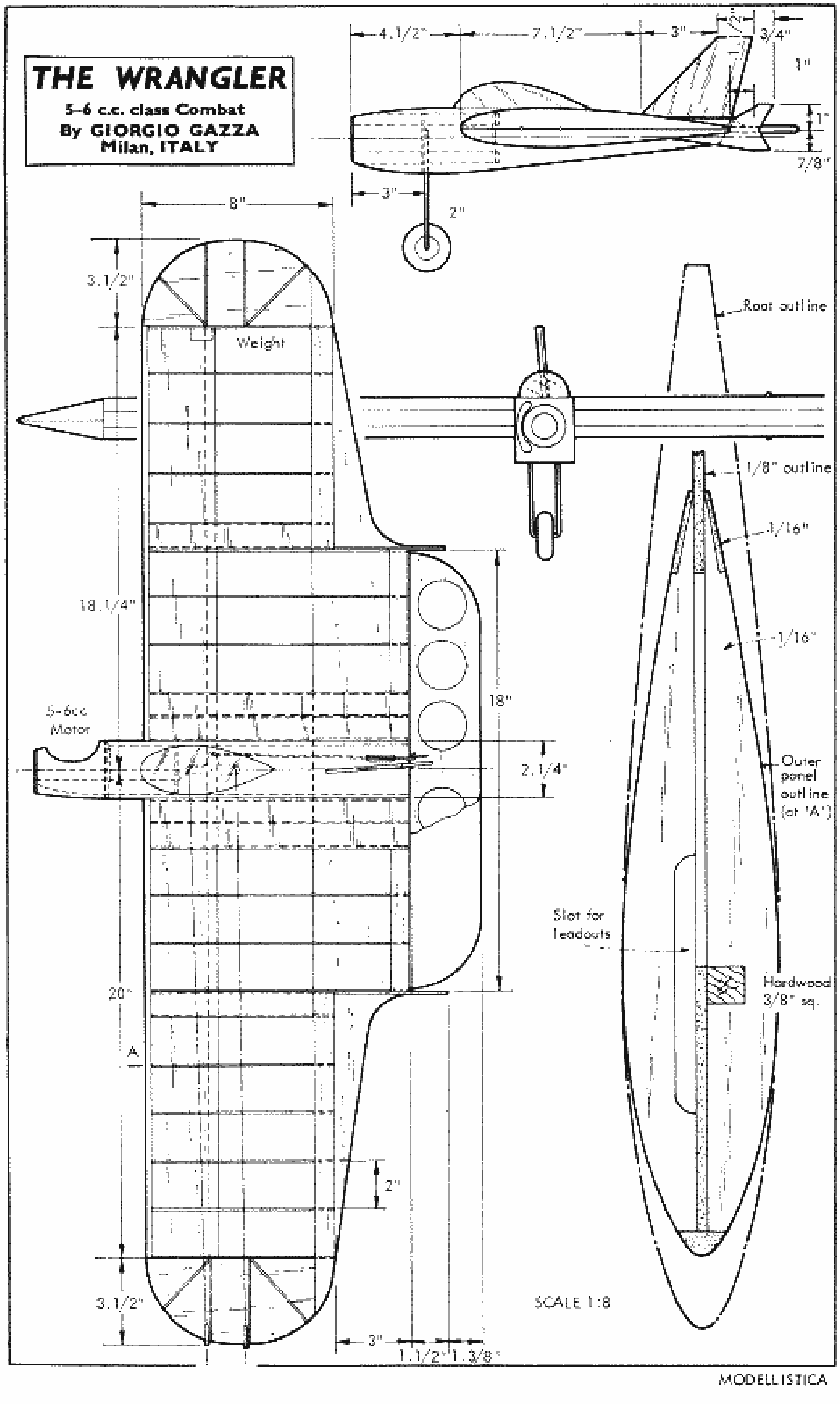
RADIO CONTROL MODELER



R/C TECHNIQUE



MODELLISTICA



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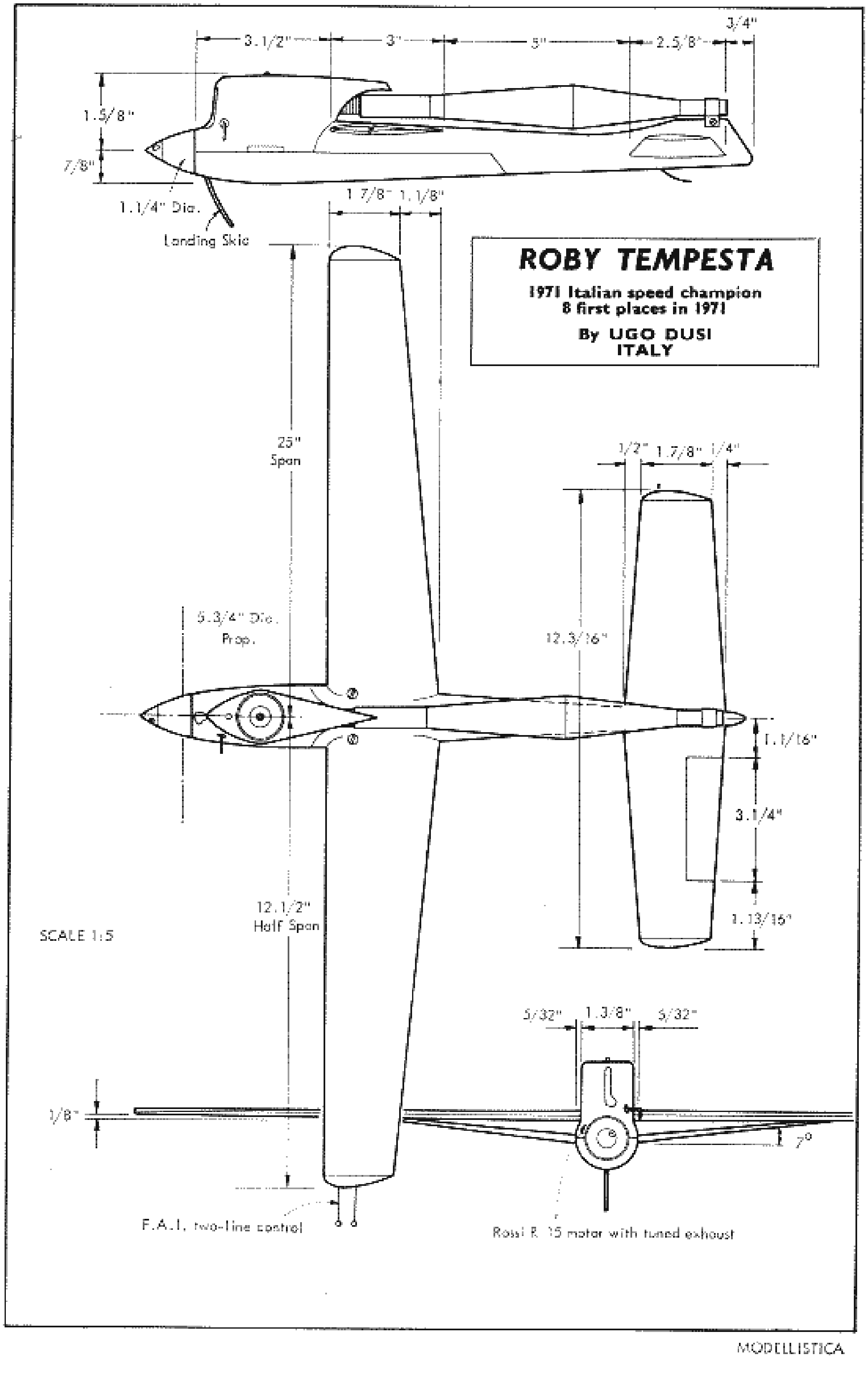

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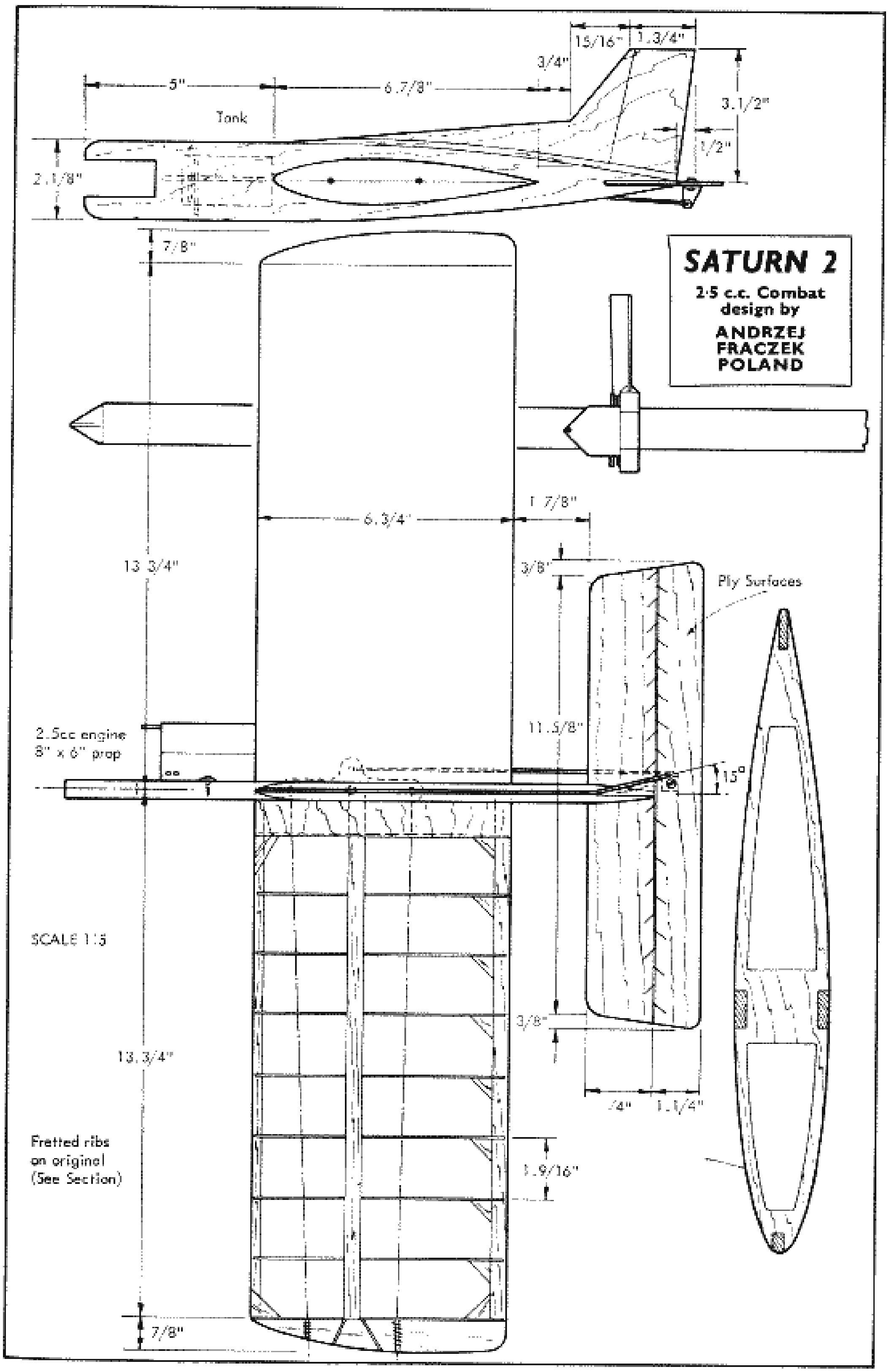


SKRZYDLATA POLSKA

DRAWING AIRFOIL SECTIONS BY COMPUTER

by Naftali Kadmon, B.A., M.Sc.

IN the June 1972 *Aeromodeller* I found an advertisement (by X-Acto) carrying a headline which so well described my attitude towards another item in the same issue—ES Airfoil Sections—that I wish to quote it in full: "*Just because you're a hobbyist doesn't mean you have to use amateur tools.*" Manually enlarging or reducing airfoil sections from a set of coordinates is a tedious business, but producing a set of templates for a single standard section which has only scale constancy to recommend it is only one way out. The modeller who wishes to employ well-tried sections for which 100-based coordinates are available, or develop his own sections, must still redraw his ribs (sorry, those of his model) at different sizes.

This can be done very conveniently with the aid of the most modern of tools—the computer. As Chief Cartographer of the Survey of Israel I have an IBM 1130 computer at my disposal, as well as a so-called drum plotter (which is an automated drawing instrument). I therefore wrote a very simple and brief program in order to have the computer, which is normally employed in plotting maps, draw airfoil sections in its spare time. A computer-cum-plotter installation is today found at many industrial, technological and academic establishments, and I am sure many readers of *Aeromodeller* have direct access if not to a computer then at least to a programmer-friend (or perhaps to that most lovely component of computer software, namely the pinkwear—which is the *terminus technicus* for a punch girl).

For the benefit of those modellers who fit this description, or who even are programmers themselves, I offer two slightly different approaches to fast automated drawing of airfoils, depending on the degree of sophistication of the computer-plotter combination. In both cases the X and Y coordinates of a section must first be punched on cards (or recorded on any other suitable input medium such as paper tape or magnetic tape). With 30 airfoil points recorded each by two coordinates of four figures (*i.e.* 8 figures for each point) this could be done on as little as three cards (a punch card has 80 punching positions or "columns")! Alternatively—and this is more convenient—we can use one card for each point on the airfoil. Let us assume that these coordinates are 100-based in accordance with accepted practice, although any other base or size would do. The computer now reads and stores these punched basic coordinate values.

Now we have to decide on the actual chord length of each rib, say C_i (this can also be easily done by the computer itself if root and tip chords as well as rib spacing are known). If we multiply each basic coordinate by $\frac{C_i}{100}$ we arrive at the actual values for drawing the section. This is, of course, exactly what we do when we project our ribs manually. But with the computer doing all the calculations, we now punch these values of $\frac{C_i}{100}$ (let's call them the scale factors for each rib) only once, and not once for each point on the section, on another set of cards, say each scale factor on a separate card.

If our plotter is slightly sophisticated and can draw a smooth curve through the given set of points, all we have to do is to employ the proper computer sub-program (which is permanently stored in the computer; we do not have to bother about this) simply by "calling" on it, and this will draw the

Fig 1 (below): FORTRAN program for plotting airfoils on a drum plotter in a series of short straight lines. Heading opposite is of a typical punch card.

```
C     PLOTTING A GIVEN AIRFOIL SECTION AT DIFFERENT CHORD LENGTHS
C
C     PROGRAM BY N. KADMON,  JERUSALEM,  1972
C
      PROGRAM AIRFOIL (INPUT,OUTPUT)
      DIMENSION X(100),Y(100),IPEN(100),X1(100),Y1(100)
      CALL NAMPLT
      CALL PLOT (10.,0.,-3)
      CALL SYMBOL (14.,0.,1.,13HN.A.C.A. 6409,0.,13)
      I=1
      PRINT 101
101   FORMAT(1H1,///,10X,*AIRFOIL SECTION COORDINATES*,//)
102   READ 103,X(I),Y(I),IPEN(I)
103   FORMAT(2F4.2,I1)
      IF(IPEN(I).EQ.9) GOTO105
      PRINT 104,X(I),Y(I),IPEN(I)
104   FORMAT(10X,2(F5.2,5X),I1)
      I=I+1
      GOTO 102
105   PRINT 106
106   FORMAT(//,10X,*SCALE FACTORS*,//)
107   READ 108,SCALE
108   FORMAT(F4.2)
      IF(SCALE.EQ.0.00) GOTO111
      PRINT 109, SCALE
109   FORMAT(10X,F5.2)
      DO 110 J=1,I
      X1(J)=X(J)*SCALE
      Y1(J)=Y(J)*SCALE
      CALL PLOT (X1(J),Y1(J),IPEN(J))
110   CONTINUE
      CALL PLOT(0.,2.,-3)
      GOTO 107
111   CALL PLOT(25.,0.,-3)
      CALL ENDPLT
      PRINT 112
112   FORMAT(///,10X,*END OF PROGRAM AIRFOIL*,/,1H1)
      END
```

line. But for each rib we first let the computer multiply the coordinates by the proper scaling factor before plotting—and presto, here comes our set of sections, neatly drawn in tiny steps on plotter paper which can be directly glued to the balsa sheet for cutting out. If, instead of on a drum plotter, we plot our sections on a so-called flatbed plotter, completely smooth curves can be achieved, although the difference between these and the "stepped" outlines drawn by the former is so small as to be of no practical significance. However, flatbed plotters are neither as straightforward to program and operate nor as commonly found as drum plotters.

The main program steps, written in the Fortran IV programming language, are given below. X(I) and Y(I) are the coordinates of the i-th point, IPEN is an instruction telling the plotter whether to lower the pen for drawing on the paper or lift it; n is any number greater than the expected number of points measured on the section, say 50; 101, 102, 103, etc., are arbitrary "statement numbers". The reading formats in parentheses should be inserted by the programmer to suit local conditions. SCALE is the scale factor given separately for each rib.

```
        DIMENSION X(n),Y(n),IPEN(n)
        I = 1
101     READ 102,X(I),Y(I),IPEN(I)
102     FORMAT (.....)
        IF (IPEN(I).EQ.9) GO TO 103
        I = I+1
        GO TO 101
103     READ 104, SCALE
104     FORMAT (.....)
        IF (SCALE.EQ.0.0) GO TO 106
        DO 105 J = 1,I
        X1(J) = X(J)* SCALE
        Y1(J) = Y(J)* SCALE
105     CONTINUE
        CALL CURVE (X1,Y1,I)
        GO TO 103
106     END
```

For technical reasons the coordinates should in this case be entered in reverse order in a continuous string, starting and finishing at the trailing edge. Furthermore, for proper spacing of the sections the pen "origin" should be moved by the program somewhat before starting on each new rib (see *Fig.* 2).

If your plotter can only draw straight lines you must supply the computer with a denser grid of points on the original section. This necessitates "digitising" the section more fully, *i.e.* measuring off coordinates of points between those supplied in the usual tables. The Fortran program outlined above must then be slightly modified: instead of statement 105 and onwards we write

```
        CALL PLOT (X1(J),Y1(J),IPEN(J))
105     CONTINUE
        GO TO 103
106     END
```

All this looks somewhat complicated, but it really is not. For those modellers interested in this method—and also for those, all envy, who still have

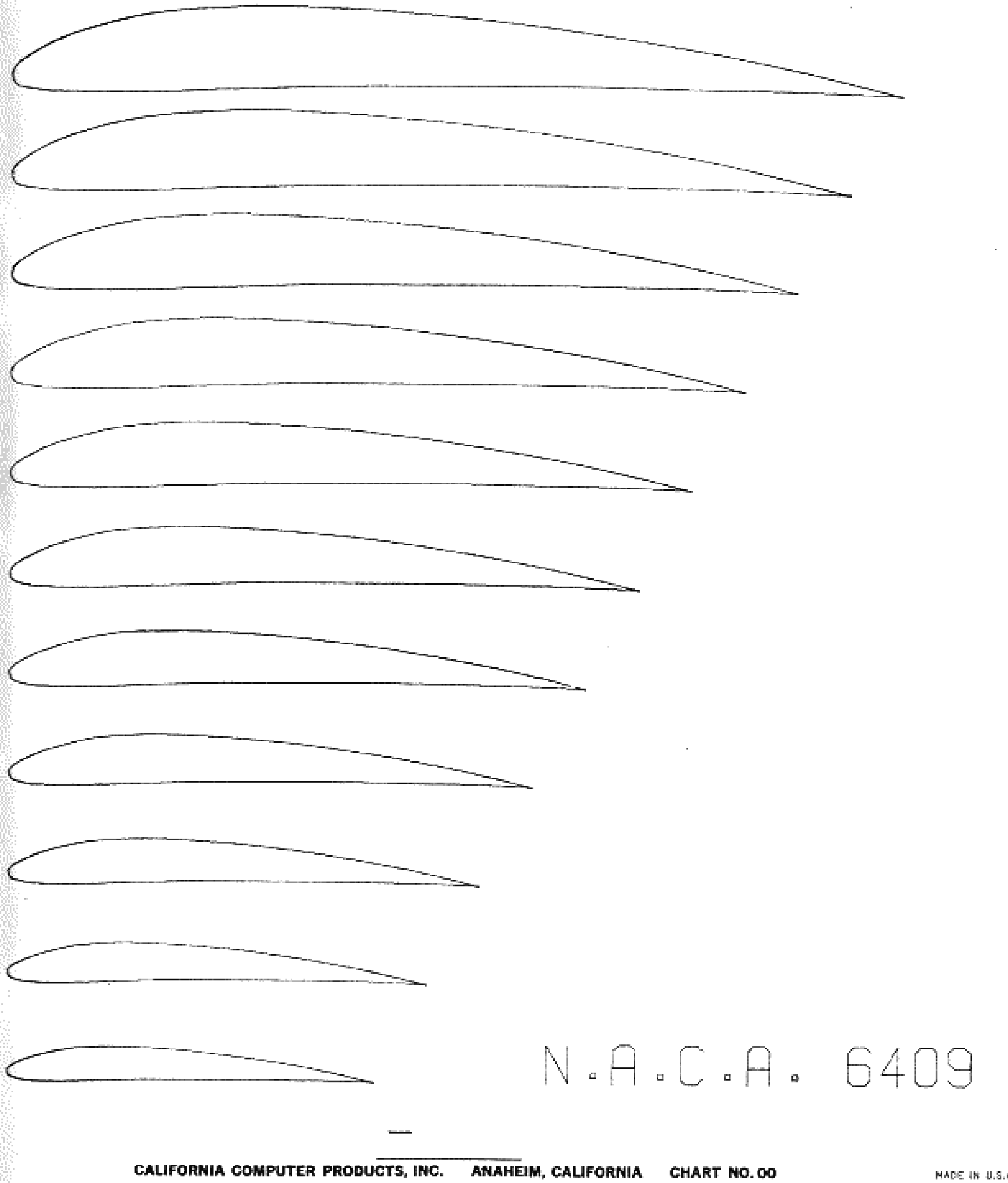


Fig. 2: A series of wing sections drawn by the program shown in Fig. 1.

to draw their airfoils the laborious way—here are a few details about operating times. Writing the program took about twenty minutes. Digitising the original section may take between 0 (if a table of coordinates is available) and half an hour. Punching both program and data takes another half-hour (unless you *are* a punch girl). But all these operations have to be done only once. Running the program varies, of course, with the type of computer employed. My own program (shown in *Fig.* 1) needs approximately 3 to 5 seconds of Central Processor time, and plotting takes some 3 to 6 seconds per rib. Now if we have drawn a set of twelve sections, say from 3 in. to 5 in. chord, and wish to draw another set of fifteen ribs from 4 in. to 8 in., this will still take only about one minute! The writer now has access to a complex flatbed plotter which will draw the rib outlines (with spar notches and all) *directly on to the balsa sheet*. But this is more than the average modeller can hope for unless he can spare some £20,000.

The program described above is, of course, quite elementary. With a suitable modification one can feed in the coordinates of different root and tip sections, even with washout, and have the computer plot all intermediate sections at their proper incidence. But since practically every quantitative problem in aeromodelling can be solved by computer I'd better stop here!

HELPING THE TIMEKEEPER TO KEEP YOUR MODEL IN SIGHT LONGER

THE following notes on colour visibility from Frank Zaic's *Model Glider Design* may squeeze a few more seconds out of the timekeeper.

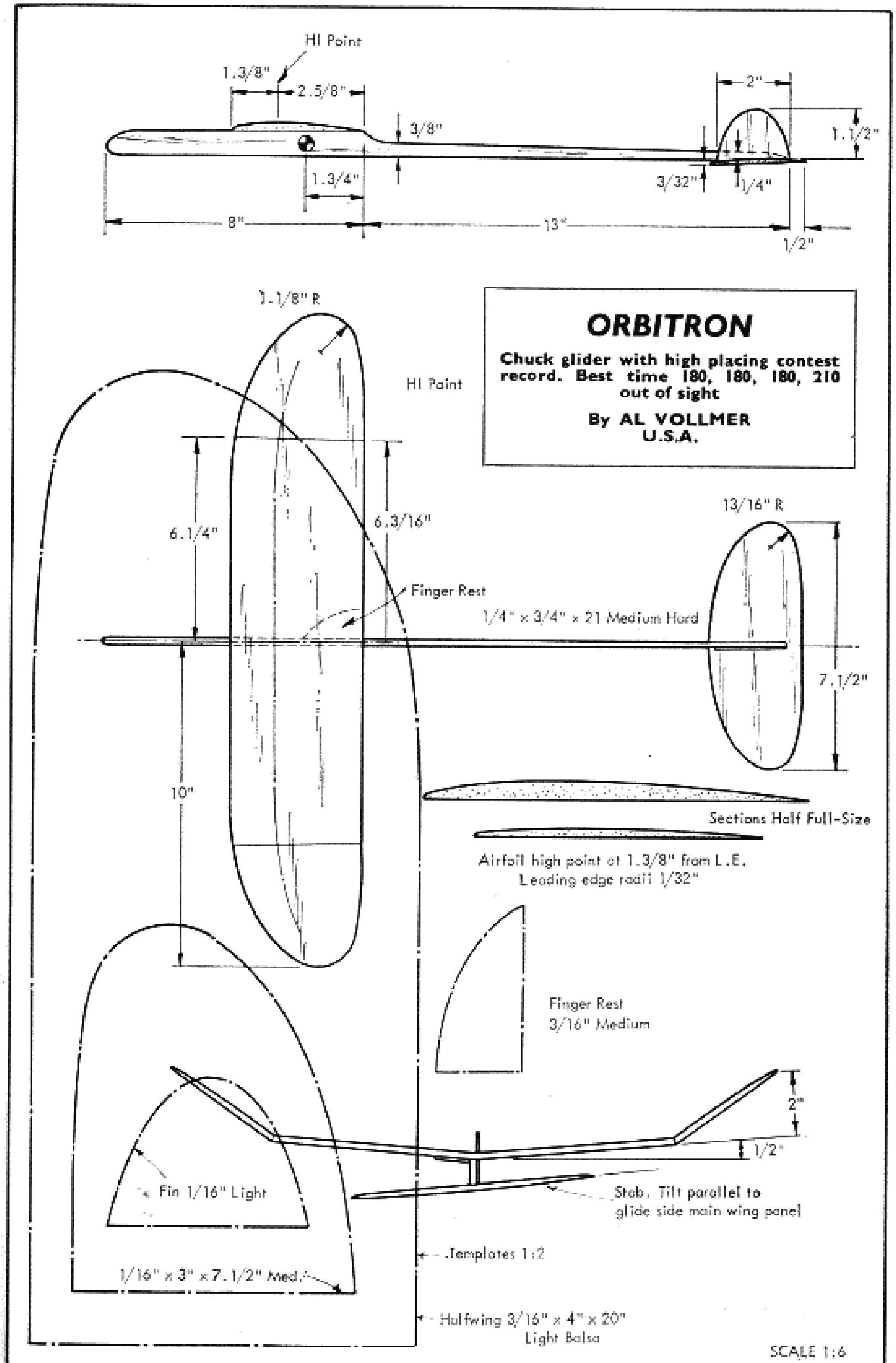
The Physical Society of London publish a table as under, giving the effective visibility range of traffic lights:

Colour	*Range in Miles*	*Colour*	*Range in Miles*
Red . .	3 to $3\frac{1}{2}$	Yellow . .	1 to $1\frac{1}{2}$
Green . .	$2\frac{1}{2}$ to 3	Blue . .	$\frac{1}{2}$ to $\frac{3}{4}$
White . .	2 to $2\frac{1}{2}$	Violet . .	$\frac{1}{2}$ to $\frac{3}{4}$

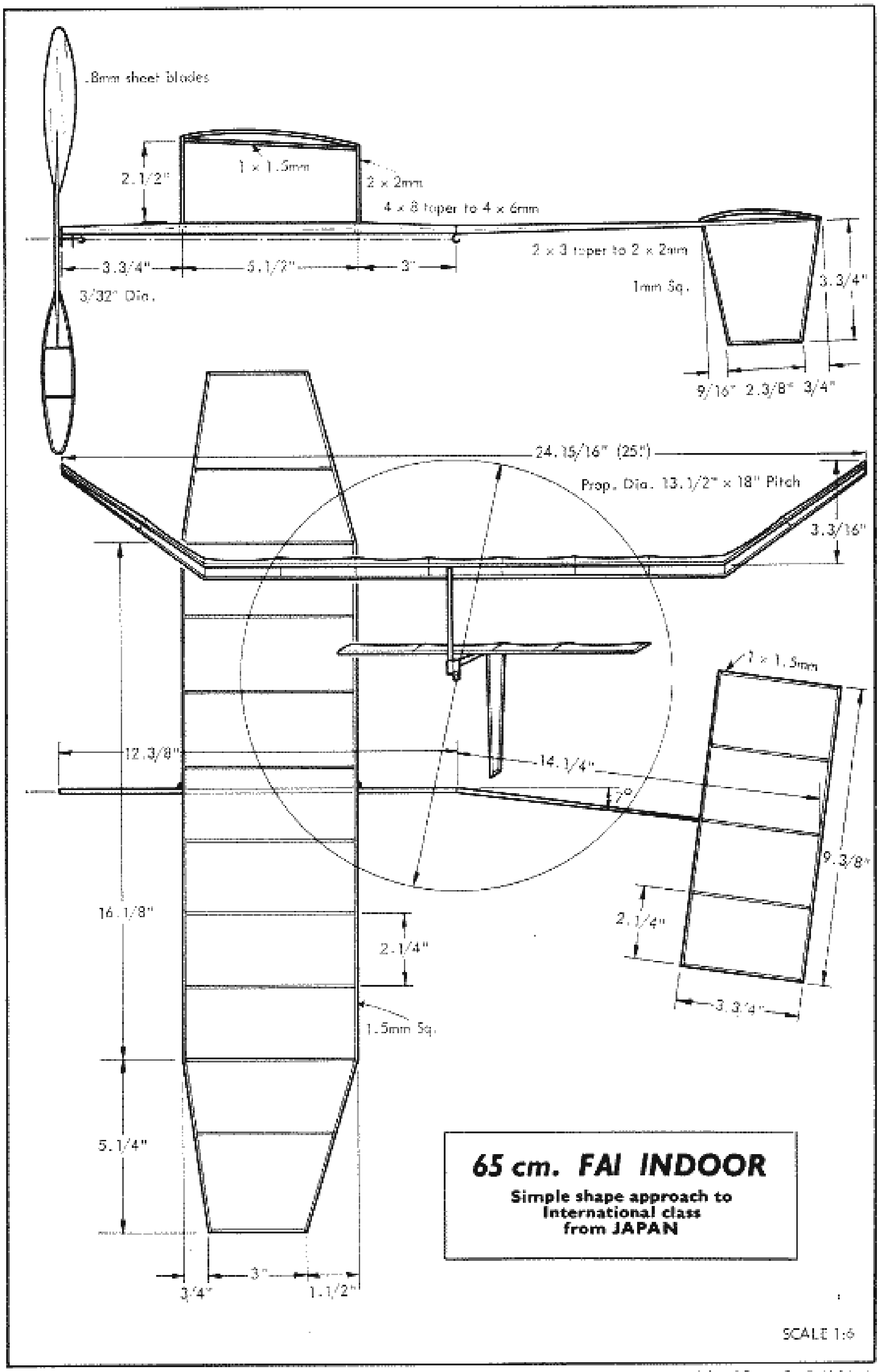
Orange yellow to vermilion orange colours have been commonly accepted after many tests in actual aircraft operation as the most visible colours contrasting with land, sky, verdure and water. These colours are also durable and resistant to fading.

Another interesting table by Le Courrier from *The Scientific American* gives legibility of various colour combinations, and though primarily intended for advertising purposes may be useful for model aircraft trimming:

Legibility Order	*Decoration*	*Background*	*Legibility Order*	*Decoration*	*Background*
1	Black	Yellow	7	Yellow	Black
2	Green	White	8	White	Red
3	Red	White	9	White	Green
4	Blue	White	10	White	Black
5	White	Blue	11	Red	Yellow
6	Black	White	12	Green	Red



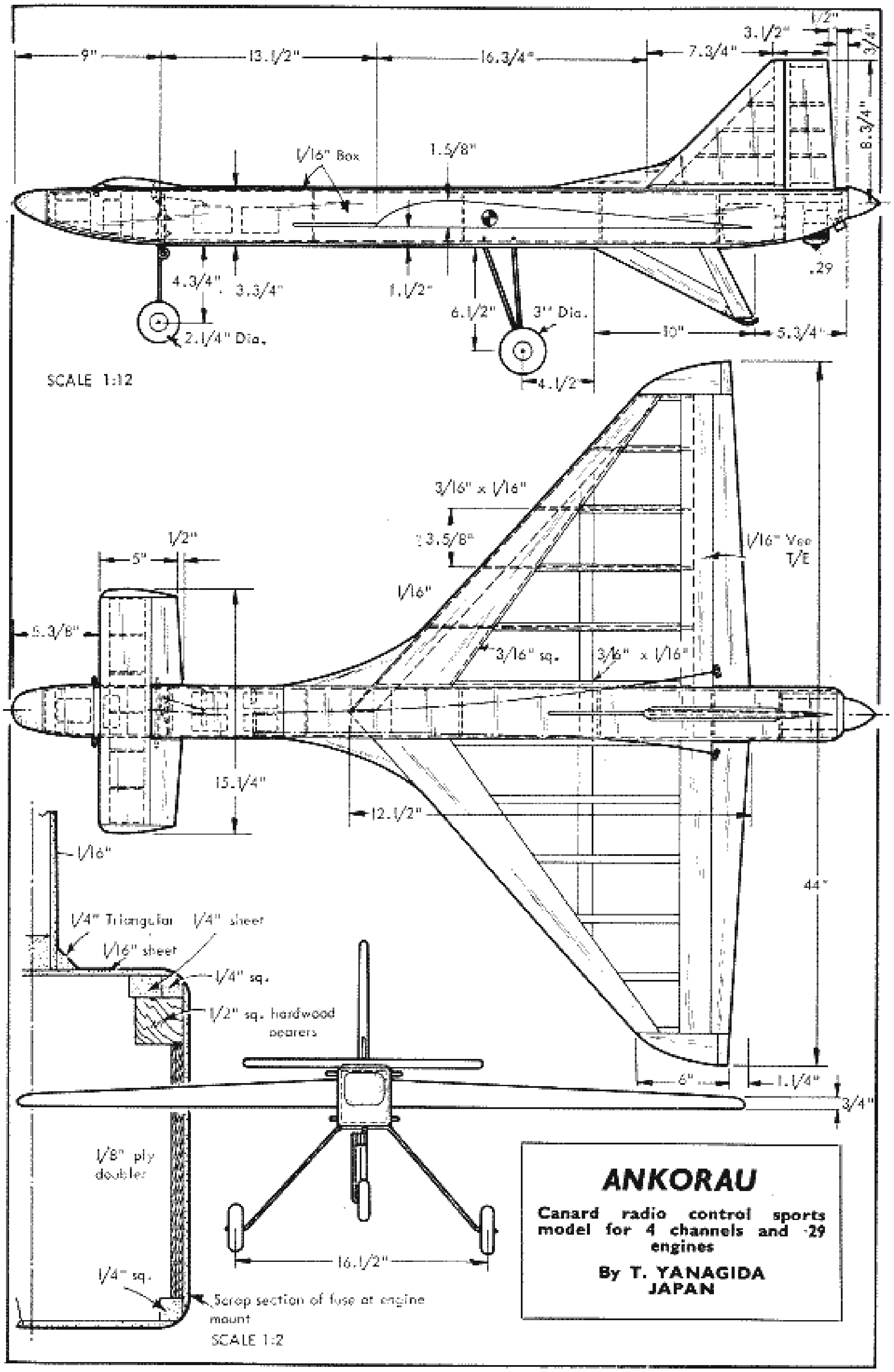
CONN-TACT USA



65 cm. FAI INDOOR

Simple shape approach to International class from JAPAN

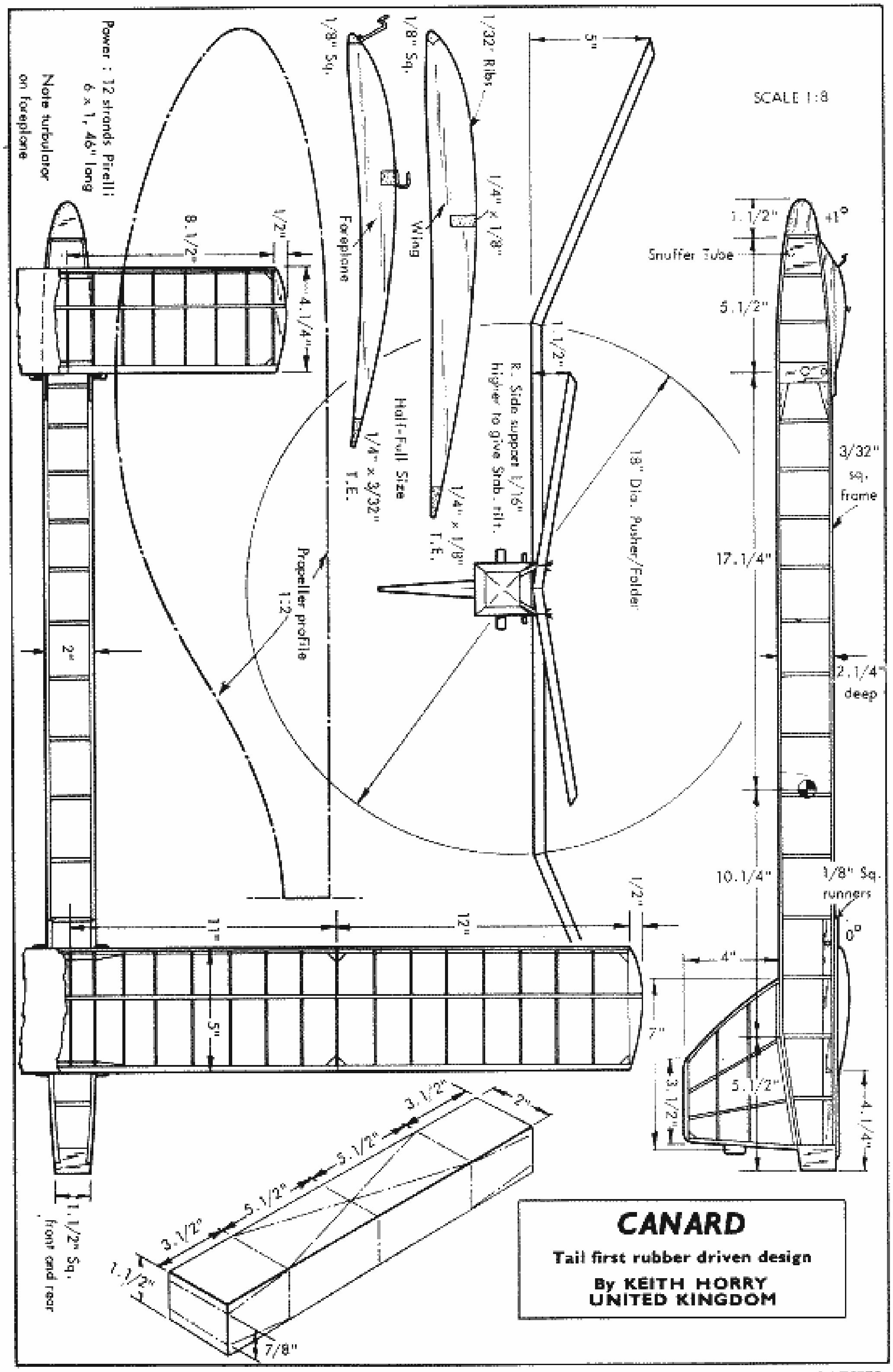
C/L TECHNIQUE JAPAN



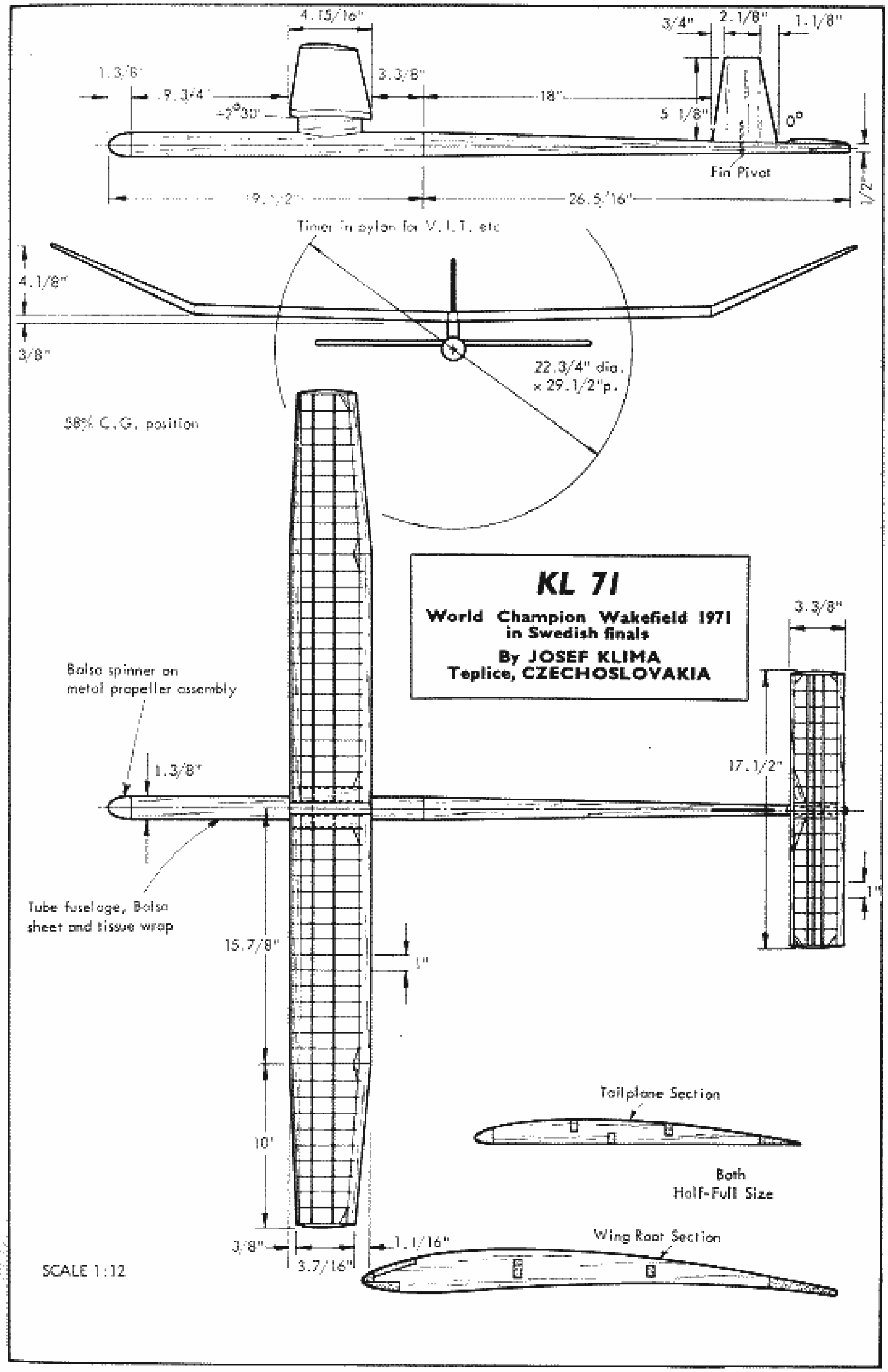
ANKORAU

Canard radio control sports model for 4 channels and ·29 engines

By T. YANAGIDA JAPAN



MODEL AEROPLANE GAZETTE



MODELAR - CZECH

DEVELOPING THE BREED—

DEVELOPMENT OF A/2 WINGS

by Jim Baguley

Author and the "Classic", his A/2 specification design which has proved to be very popular since publication in *Aeromodeller*—see reproduction of plan opposite. Full size copies are available price 50p from Aeromodeller Plans Service, 13/35 Bridge Street, Hemel Hempstead, Herts.

THE design of an A/2 glider is inevitably a compromise. This is because many of the features which increase "unaided" performance decrease stability, and to provide a perfect solution can result in a complicated model which then defeats two other features which are desirable in a contest model, expendability and reliability.

This article is mainly aimed at the development of A/2 wings as a supplement to the "*Classic*" feature in the June 1972 *Aeromodeller* and my own developments in this respect; the remainder of A/2 design being fairly stereotyped these days, except for gadgetry, based usually on a 26 in. to 28 in. tail moment with 80 to 75 sq. in. tailplane of section to suit that of the wing.

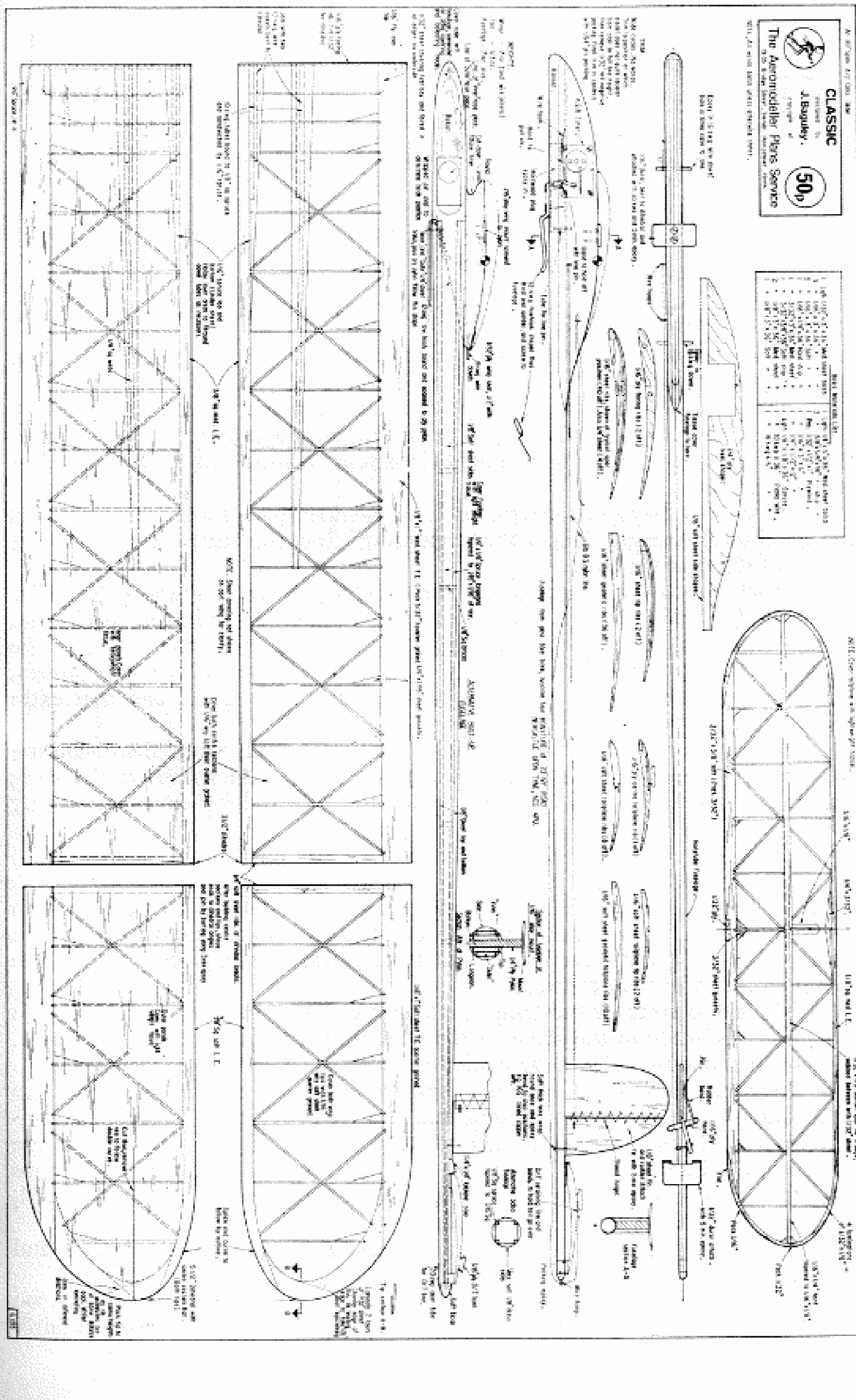
To explain the opening paragraph, consider the findings of Peter Allnutt and Kenneth Kaczanowski published in the 1971/72 *Annual* and of common knowledge from basic aerodynamics. The following changes to wing features all increase unaided performance if kept within certain limits:

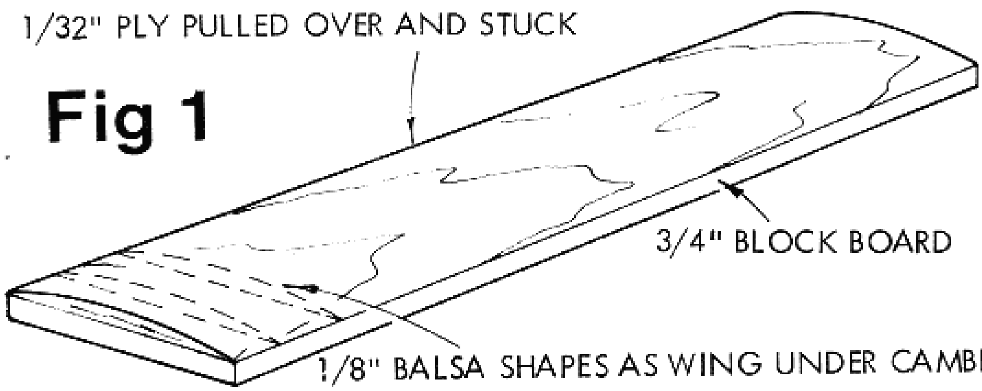
(i) Increase of aspect ratio.
(ii) Decrease of section thickness.
(iii) Increase of section camber.
(iv) Location more rearward of section, maximum camber.

They all tend to decrease stability, longitudinally or laterally, and (i) and (ii) affect wing rigidity, improvements in which can increase wing weight and further affect lateral stability.

Wing shape is another variable with little meaningful data to support various preferences. I believe that a bluntish, rounded tip shape with section taper to a sharp edge is relatively efficient but some "still air" models with very good duration have plain blunt ends to the wings!

Dihedral breaks and wing-to-fuselage joints have some effect but on a practical contest model it seems not to be worthwhile having "curved" tip


CLASSIC
J. Baguley
The Aeromodeller Plans Service
50p



dihedral and most "drag-free" wing mountings, *e.g.* slender pylon, are either complex or too flimsy.

Before covering some of the practical development stages, a few general words on construction design might be useful, although John O'Donnell gave some very good ones in his "Free Flight Comment" feature that regularly appears in *Aeromodeller*.

Use fairly large wood sizes, *not* a lot of small spars, for easy construction and good local strength. Taper the strength off from the centre and use lighter grades of wood at the tips.

Use adequately strong joiners for two-piece wings, *e.g.* twice 10g. wire dowels and, if using these, fix the tubes fairly securely to the main spar(s) and leading edge and possibly trailing edge for continuity of strength, so that the ribs are not taking a load for which they are not intended. Also, with wire joiners, remember that the end of the joiner is the main stress point and that extra strengthening should taper off after this.

Use spruce liberally but taper it off rapidly. Locally strengthen handling points and rubber band bearing positions, *e.g.* sheet underneath at the wing centre, plywood facing ribs, plywood added over the trailing edge at the wing centre, etc.

Use geodetics where the wing section is fairly thin.

Strengthen the ends of weak rib trailing edges with gussets.

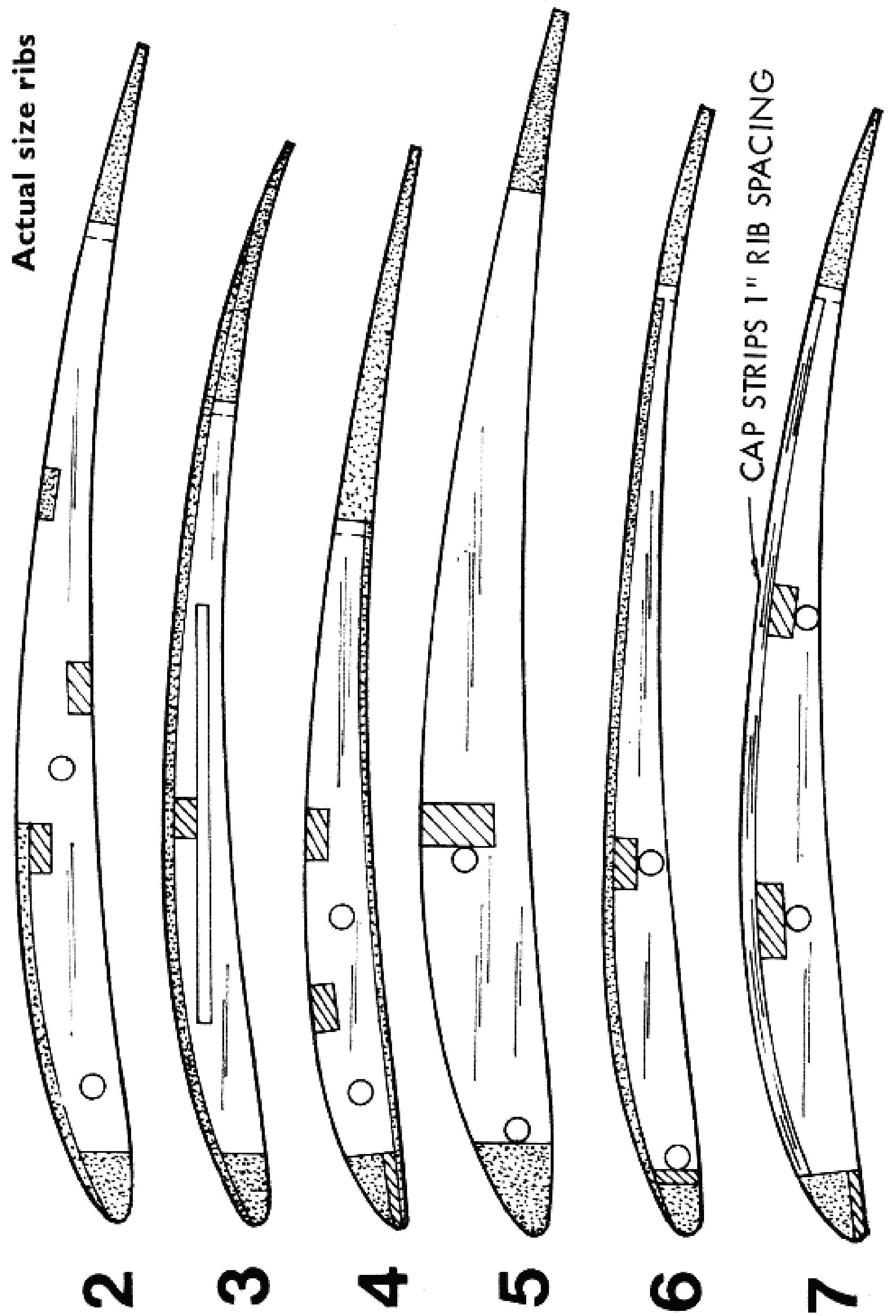
Make tips break off easily to avoid complicated damage by butting them at two thick ribs. They can then be epoxied on quickly in a contest with no trim change. Make all joints accurately and force nothing into place; this will be repaid by a lack of trim changes.

An aid to accurate building which enables me to build as quickly as I do is a simple jig made to the shape of the wing undercamber as shown in *Fig.* 1. If more than one model is to be made, it is well worthwhile in time alone.

Around 1964 I had finished with a fairly standard 6 in. chord, tip dihedralled wings, using the section and construction shown in *Fig.* 2. Constructionally, the bad points are the load taken by the ply centre ribs which bear the wire dowel joiners, and the abrupt change of stress at the end of the wire dowels, since the spruce spars in the centre section were not tapered. It did, however, take quite a load to break them.

In arriving at the start of the present series there were a few experimental deviations, some of which are shown in *Figs.* 3, 4 *and* 5.

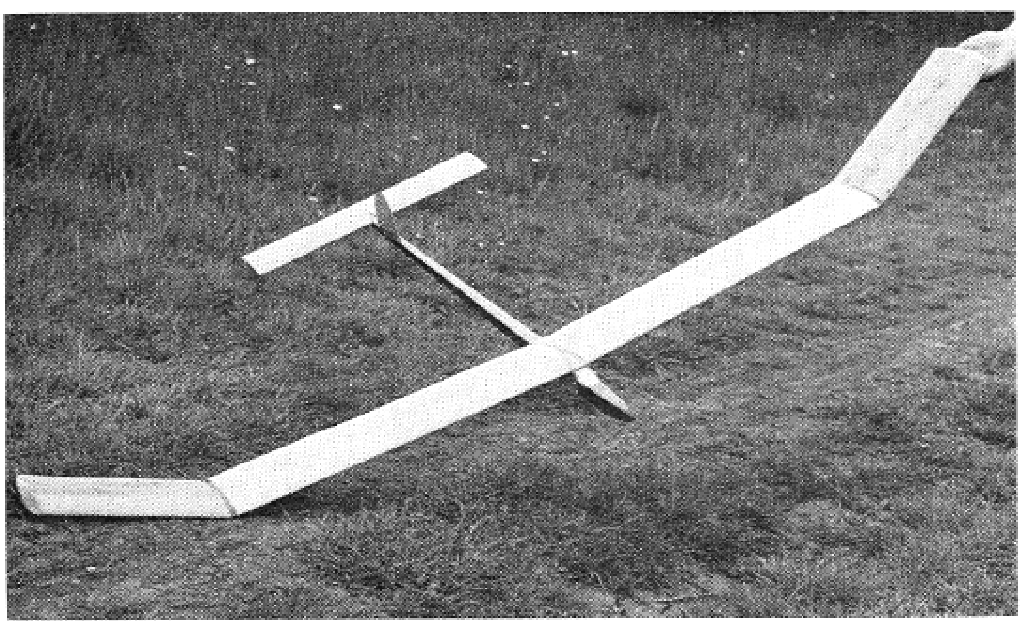
Fig. 3 is the Lindner wing which I found to have taken performance too far for all-weather stability (mine was well made and trimmed). It seemed fairly

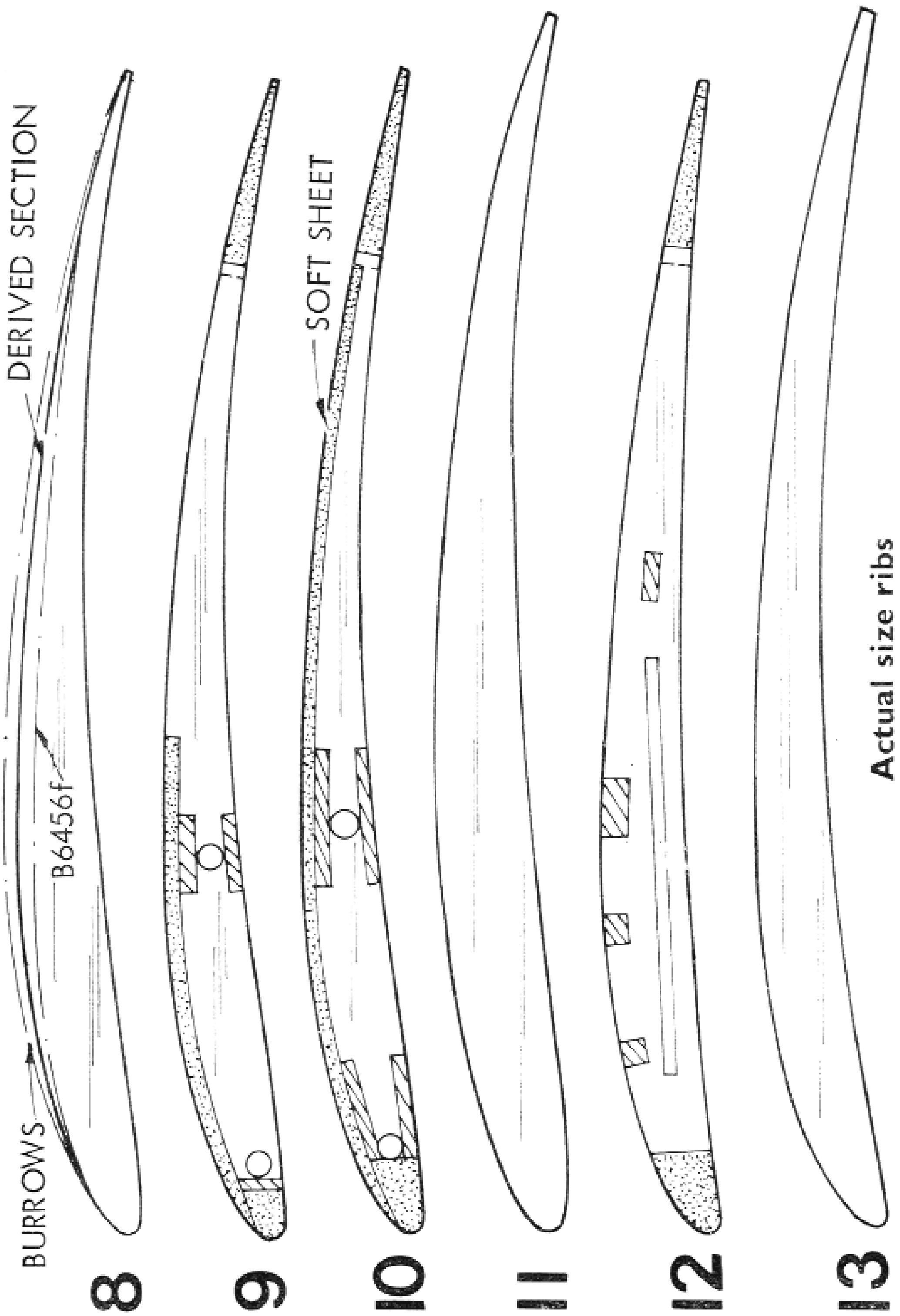

Actual size ribs
CAP STRIPS 1" RIB SPACING
2
3
4
5
6
7

Author with the "Classic" at left, shows the slender fuselage and emphasises the airfoil under-camber in this photo angle—see Fig. 10 for the section. Below is the prototype of the KeilKraft "Aquarius" kit, which will revolutionise A/2 model construction with use of pre-moulded plastic ribs.

strong, probably because of the fairly high camber and flexible aluminium alloy joiner, but it had a tendency for the edges of the tongue to break out of the top surface at the centre and is not a very good stress proposition consequently.

Fig. 4 is the B7457d/2 which was popular for a while, particularly in the U.S.A. I used it with sheeted upper surface and the illustrated copy of Norman Ingersoll's design. Without dwelling on the obvious follies in the illustrated construction, I, in common with others, found the section to have very variable stability results despite all manner of trim changes and use of turbulators.





Actual size ribs

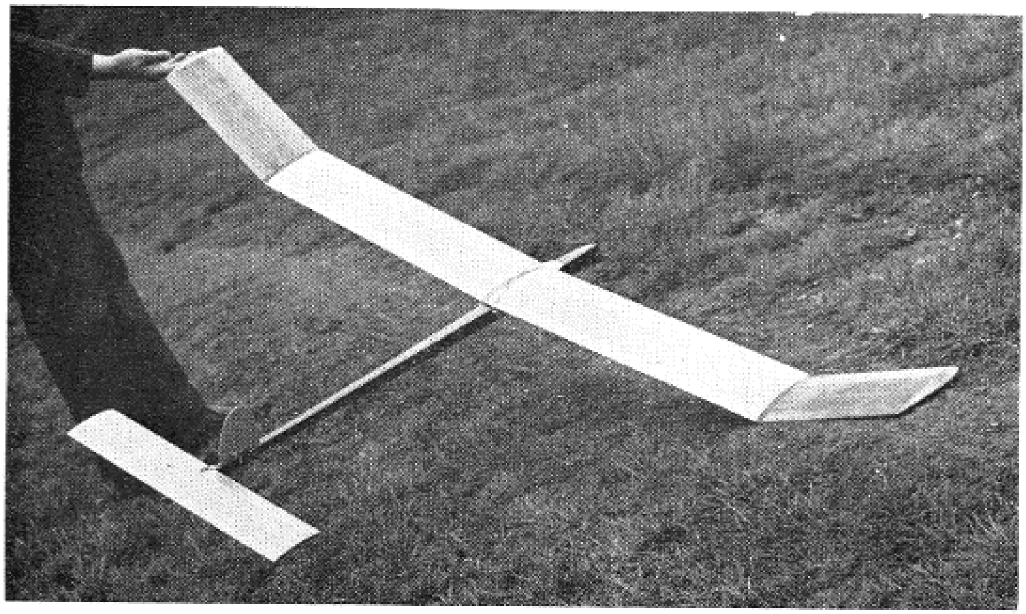


Fig. 5 is the Davis ·93/·17 and with a section of this thickness and a $6\frac{1}{4}$ in. chord you can get away with even the simple construction shown! It is not a "gliding" section but it is surprising to observe that certain well-known designs do glide well with it.

The B6456F shown in *Fig.* 6 was the first of the present series, leading to the "*Classic*". It was (as now) used on a $5\frac{3}{4}$ in. chord, which I consider a practical minimum for all-round contest flying. It was too flexible and would not retain a trim. A way could not be seen to rectify this without considerable weight or complexity increase so, despite a very good glide, it was discarded (after making a solid sheet pair of wings which weighed 10 oz.!).

Mike Burrows' section in *Fig.* 7 (or *one* of several of them!) was tried out and fared better but did not glide as well and was still too flexible torsionally. It was very strong in bending, as have been all subsequent wings, owing to suitable joiner anchorage and spar tapering.

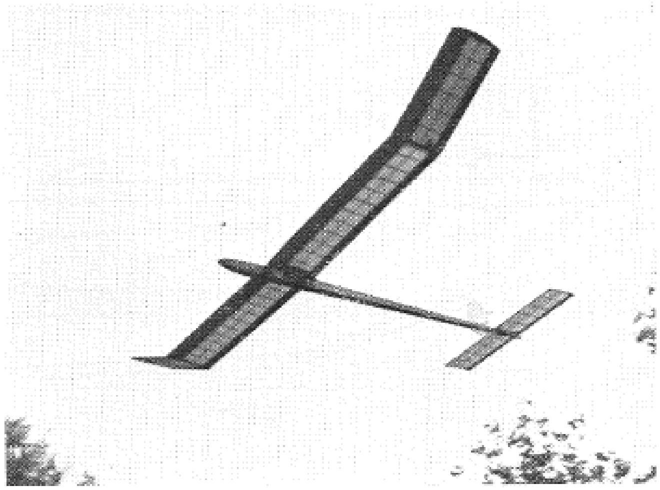
It was realised at this time that the B6456F and Burrows' sections had nearly identical undercamber. It was therefore decided to try a section having the average of the upper surfaces. This is not a very scientific procedure but I doubt if many of the sections used by modellers are created in a better way! It has been used since and has proved successful, enabling a reliable construction to be developed and having a good "unaided" performance.

The section derivation is shown in *Fig.* 8 and the construction used on a number of models in *Fig.* 9, which was still too flexible in windy conditions despite diagonal ribs aft of the main spar.

Obviously decrease of aspect ratio or increase of section thickness would rectify this but at the expense of performance, so the "*Classic*" construction in *Fig.* 10 was designed.

With "Union Jack" rib construction, it is torsionally rigid. The spruce 'I' spar and leading edge strengthener, to which the joiner dowel tubes are anchored, taper after the dowel ends to nothing about halfway along the centre section. The additional use of a ply facing rib makes a very strong wing which has yet to break on tow.

Opposite, and at right: Two views of the Jim Baguley designed KeilKraft "Aquarius" which has a Benedek section; see Fig. 11 on page 69, with the ribs supplied in plastic. Note the simplicity of the design, which will make it a favourite among sports fliers as well as contest enthusiasts.



A version with more top camber, more like the original Burrows' section, has been tried but was not trimmable until turbulated. Even then the stability was inadequate. Reasons can be invented to explain this, the most likely being that the tissue covered Burrows' sections have less top camber due to tissue sag and may also be turbulated in just the right fashion by the ridge at the back of the leading edge.

Other well-known sections are shown in *Figs.* 11, 12 *and* 13.

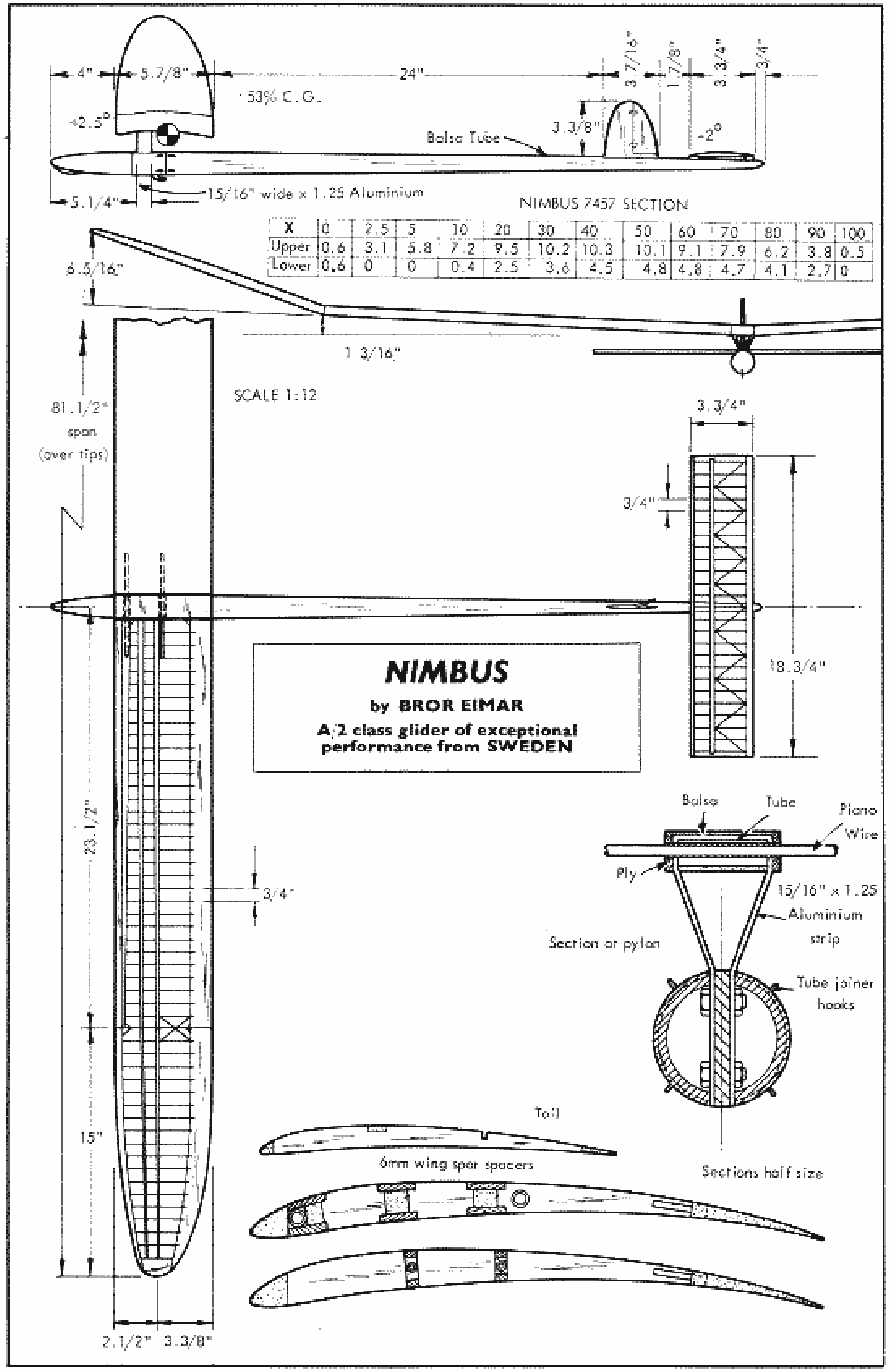
Fig. 11 is the B8586b I used on the KeilKraft *Aquarius.* It is a good reliable section of moderate gliding capability and is sufficiently thick for easily achieved strong construction, *i.e.* ideally suited for a kit model.

Fig. 12 is the Hirschel section reputed to be a B6356b, but seeming to be a little thick, particularly at the trailing edge. In Jim Punter's hands, it glides very well and gives adequate strength on his *Graduate* with similar construction to the *Classic.* Using the construction shown as on Hirschel's 1967 A/2 World Championship winner, I found it very flexible upwards with little uneven twist to cause weaving on tow, but not equal to very windy conditions at the high stress point at the end of the tongue.

Fig. 13 is the Kaczanowski GF6 which should have, as reputation says, an excellent glide, but the camber is rather extreme and one wonders at the turbulent air stability.

After all this, what are present-day trends?

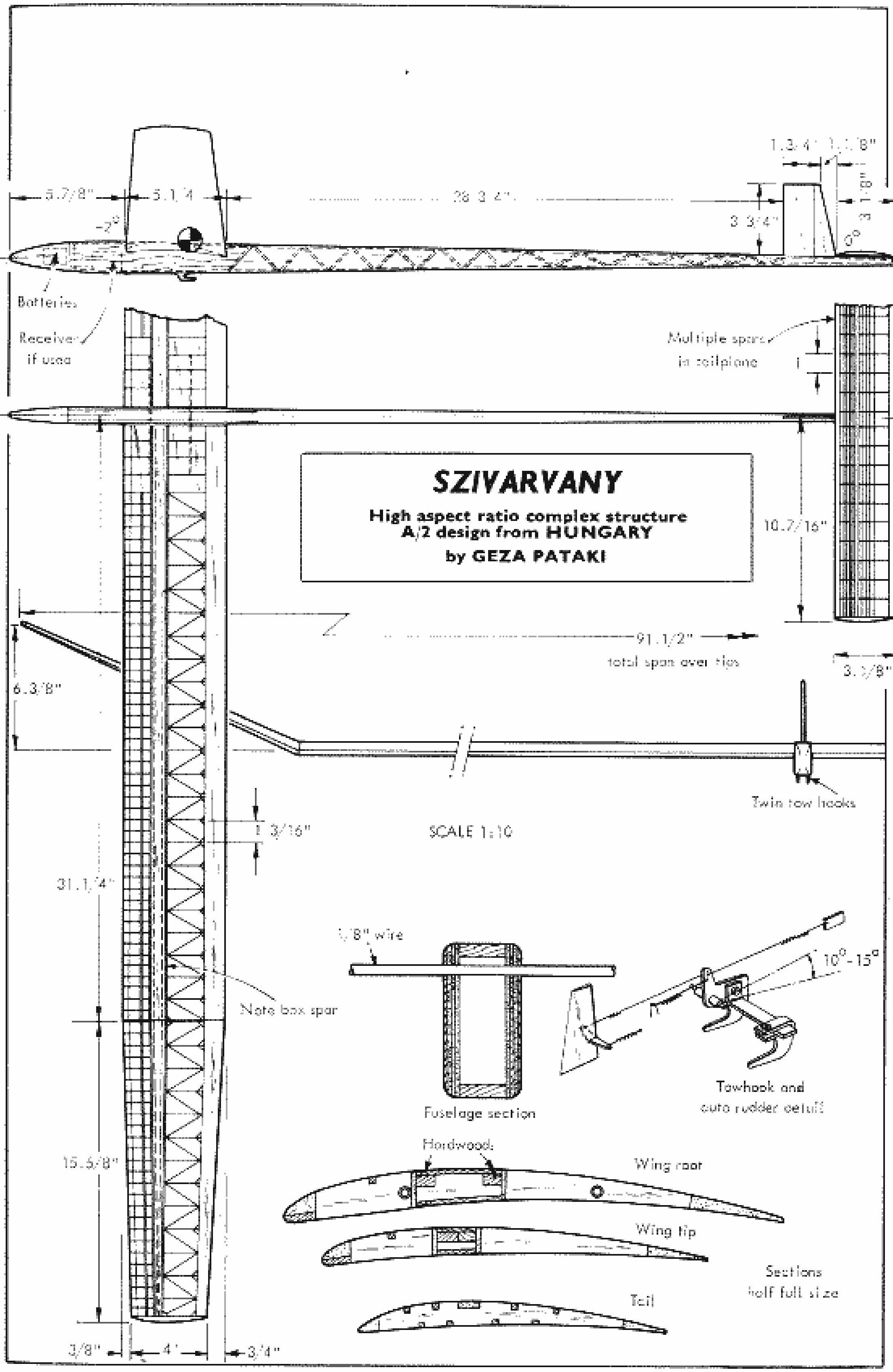
Frankly, simplicity and stability are felt to be more important in these tactical flying days. A good glide is often important; but for most contests is rarely needed to be better than that of the *Classic* or similar designs. There is a tendency to go back to 6 in. chord designed with less cambered sections. After the extremely windy conditions of the 1972 British season I am tempted to build one of these—they bounce better off runways!



NIMBUS 7457 SECTION

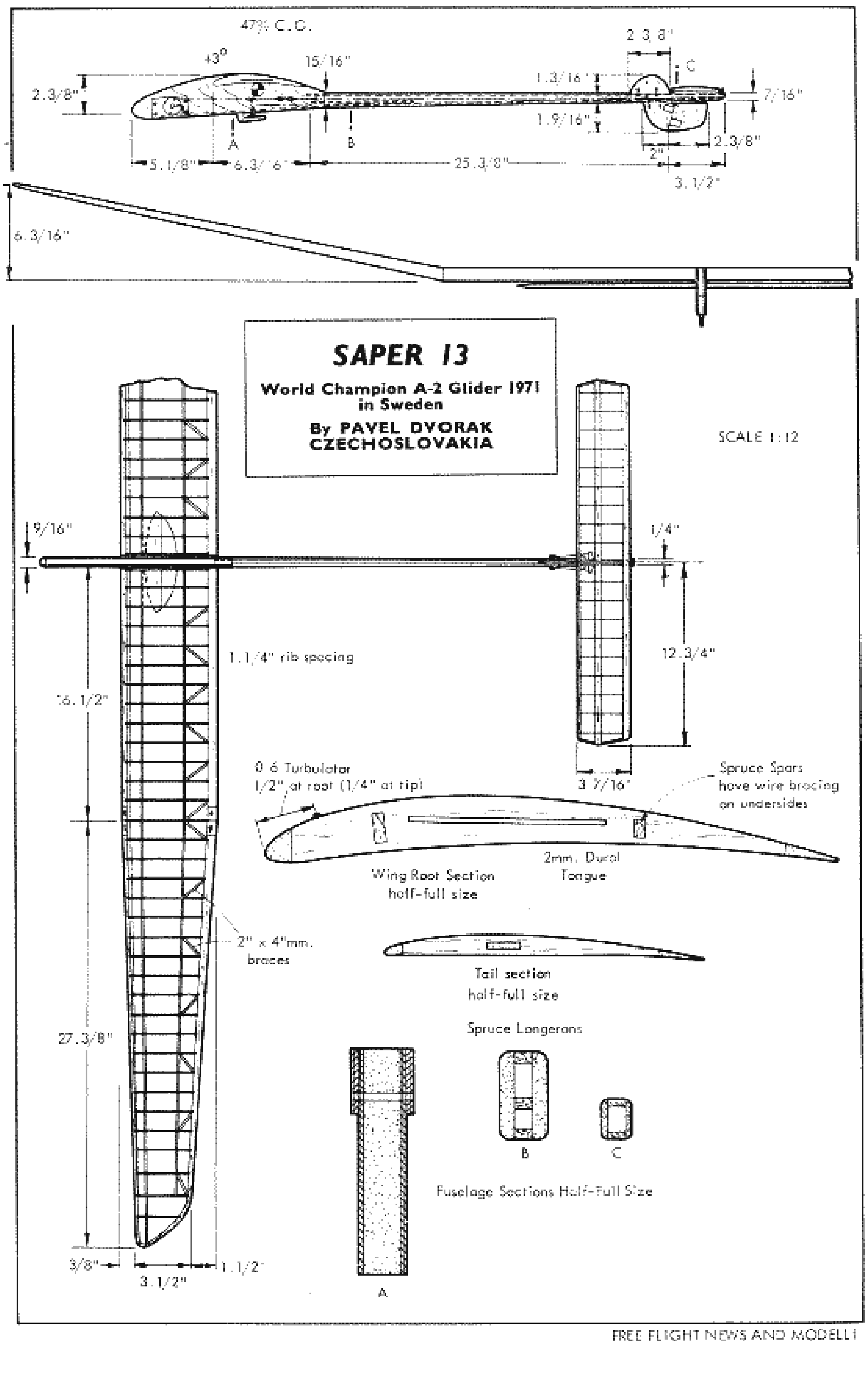
X	0	2.5	5	10	20	30	40	50	60	70	80	90	100
Upper	0.6	3.1	5.8	7.2	9.5	10.2	10.3	10.1	9.1	7.9	6.2	3.8	0.5
Lower	0.6	0	0	0.4	2.5	3.6	4.5	4.8	4.8	4.7	4.1	2.7	0

STABBEN

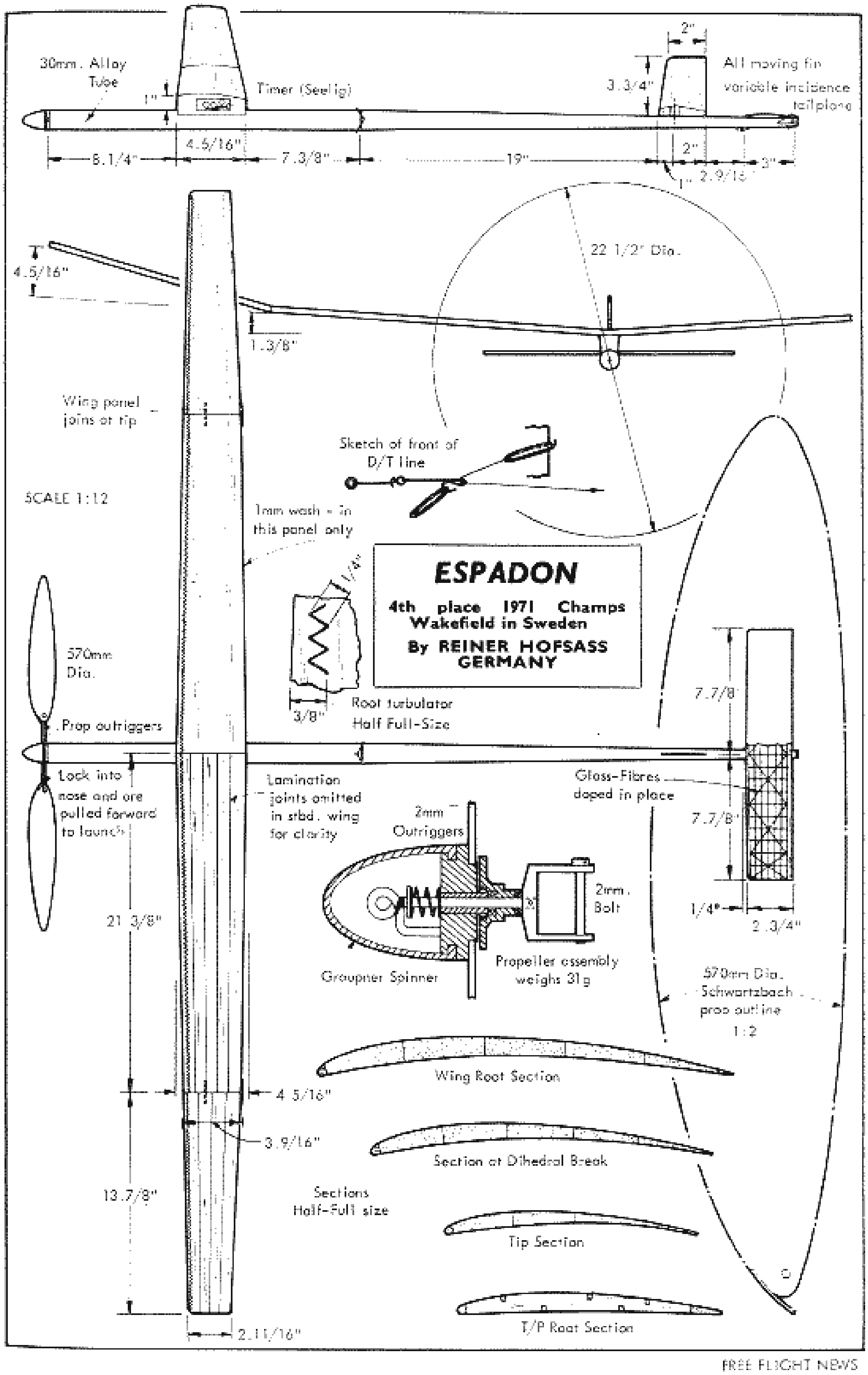


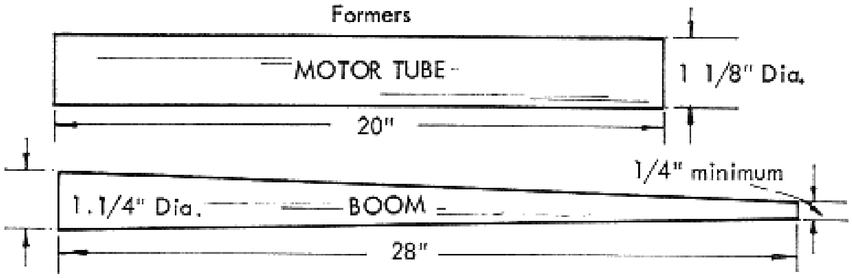
SZIVARVANY
High aspect ratio complex structure
A/2 design from HUNGARY
by GEZA PATAKI
SCALE 1:10
5.7/8"
5.1/4
-2°
Batteries
Receiver if used
Multiple spars in tailplane
10.7/16"
91.1/2"
total span over tips
6.3/8"
Twin tow hooks
1 3/16"
31.1/4"
15.5/8"
3/8"
4"
3/4"
Note box spar
1/8" wire
Fuselage section
Towhook and auto rudder detail
10°-15°
Hardwood
Wing root
Wing tip
Tail
Sections half full size

MODELLEZES



FREE FLIGHT NEWS AND MODELLI


30mm. Alloy Tube
1"
Timer (Seelig)
2"
3.3/4"
All moving fin variable incidence tailplane
4.5/16"
8.1/4"
7.3/8"
19"
2"
3"
1"
2.9/16
22 1/2" Dia.
4.5/16"
1.3/8"
Wing panel joins at tip
Sketch of front of D/T line
SCALE 1:12
1mm wash - in this panel only
1/4"
ESPADON
4th place 1971 Champs Wakefield in Sweden
By REINER HOFSASS GERMANY
570mm Dia.
3/8"
Root turbulator Half Full-Size
7.7/8"
Prop outriggers
Lock into nose and are pulled forward to launch
Lamination joints omitted in stbd. wing for clarity
Glass-Fibres doped in place
2mm Outriggers
7.7/8"
2mm. Bolt
1/4"
2.3/4"
21 3/8"
Graupner Spinner
Propeller assembly weighs 31g
570mm Dia. Schwartzbach prop outline 1:2
4 5/16"
Wing Root Section
3.9/16"
Section at Dihedral Break
13.7/8"
Sections Half-Full size
Tip Section
T/P Root Section
2.11/16"

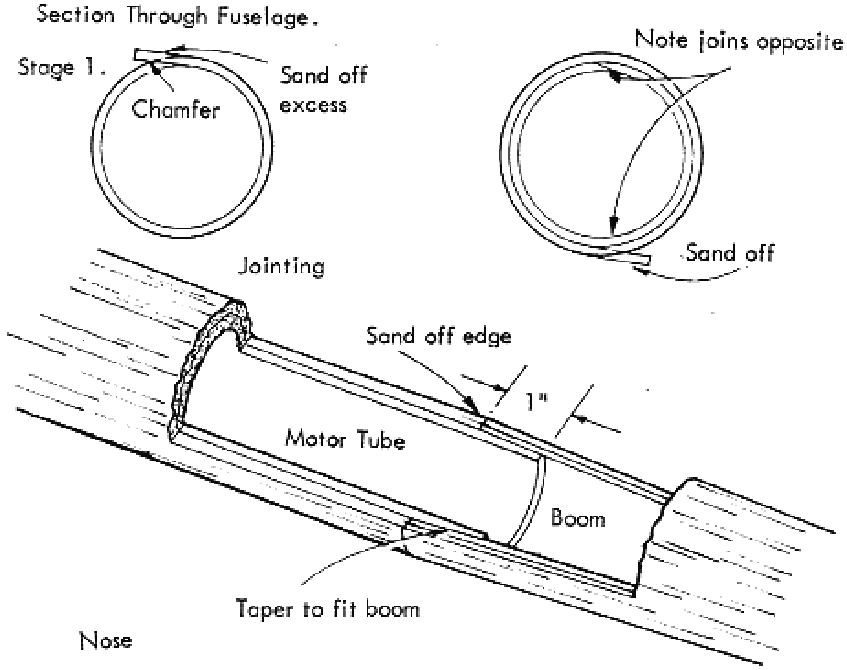


Note Boom 1.1/4" Dia. compares with 1.1/8" Dia. motor tube

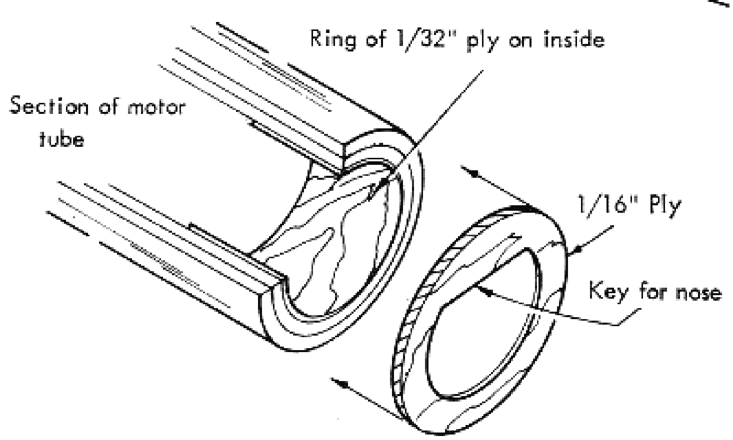
2 Laminations of 1/16" sheet on motor tube = 1.3/8" Dia. outside

2 Laminations of 1/32" sheet on boom = 1.3/8" Dia outside max.

Section Through Fuselage.



Nose



Boom This is an identical process but more care is needed due to the smaller diameter at one end on the taper. This can be made easier by working from the *narrow end* first.

Jointing Is facilitated by leaving the inside lamination 1 in. or so larger than the outer and the boom is slipped over and glued in place.

Finish The nose can be completed by addition of a ply face and reinforced ring. Tail end can be finished off with soft block. Plywood motor peg mounts can be let in. Pylon, fin, etc., can now be added and the fuselage finished ready for covering.

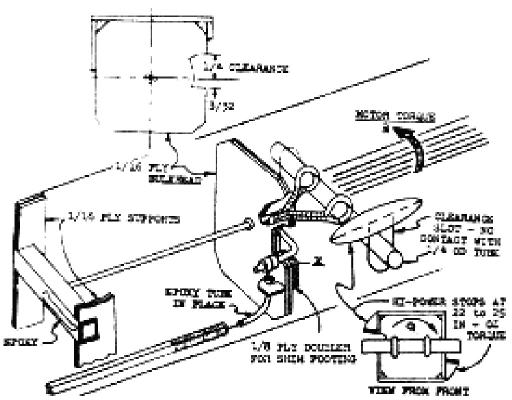
Conclusion

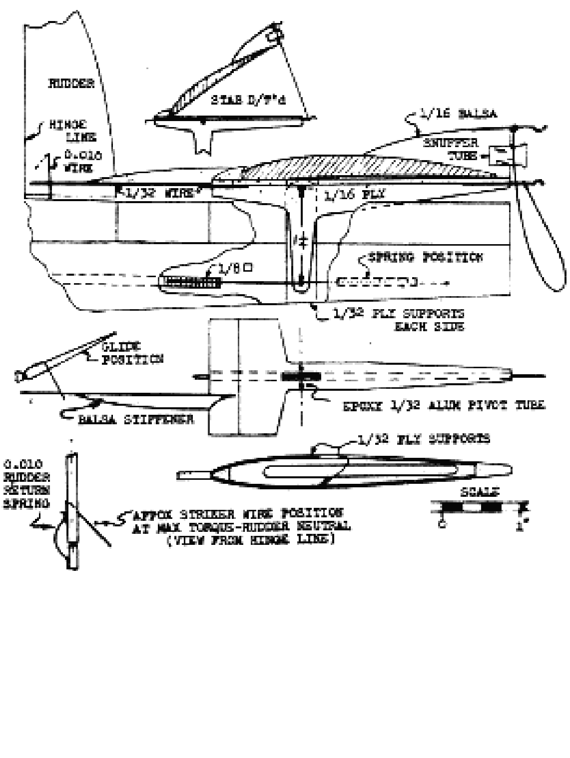
Further strengthening can be made easier by interleaving silk or nylon between the laminations to protect against motor breakages. However, the writer's preference is to use a winding tube to protect against breakage and ingress of lubricants as well as permitting the easy removal of broken motors.

TORQUE OPERATED VARIABLE INCIDENCE TAIL

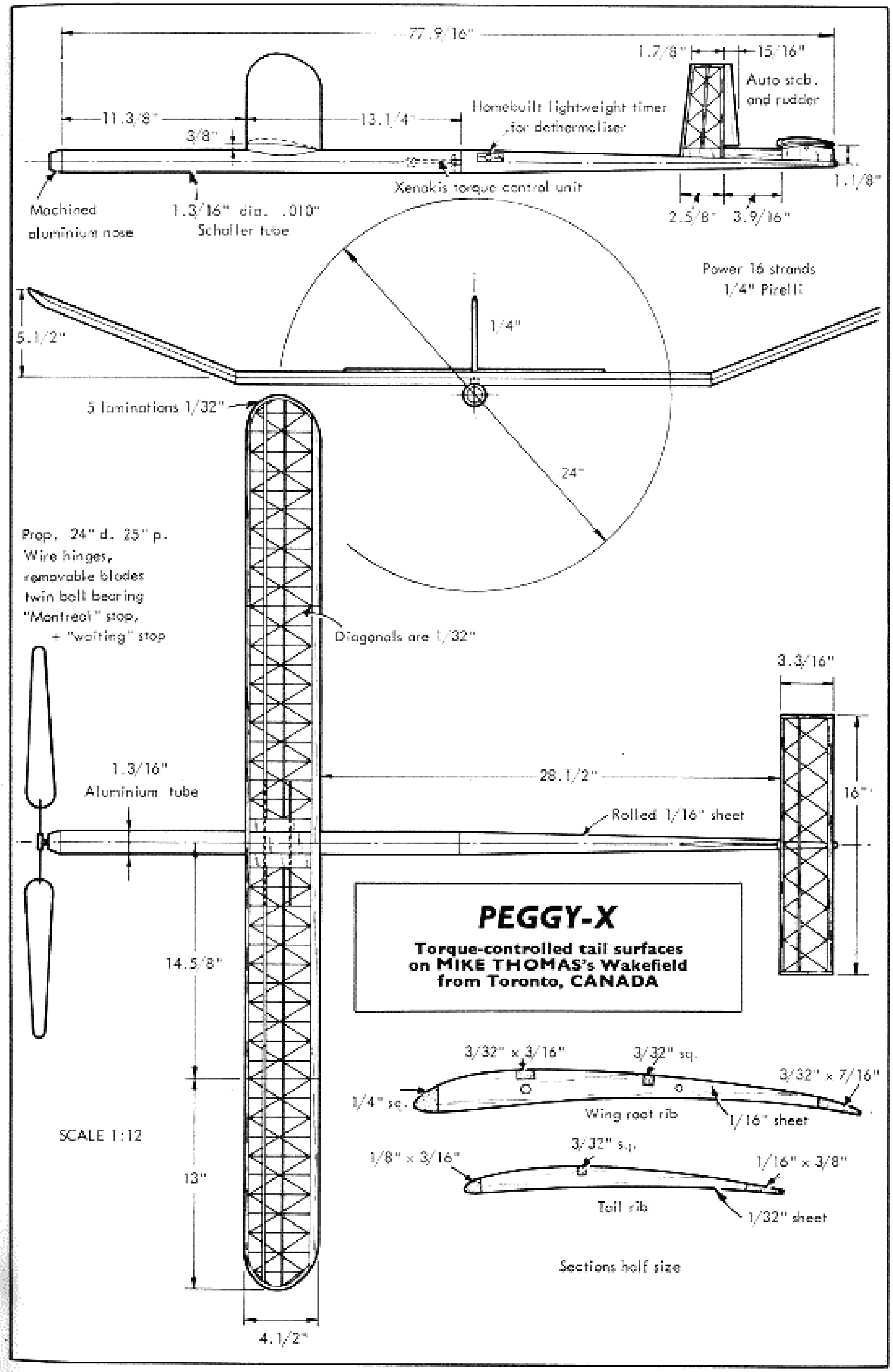
by George Xenakis

THE torque rod installation, below left, shows how the torque rod and the drive-pin motion-transmitting tube and wire are installed in the fuselage. Note that the drive-pin should be resting against the bottom of the notch in the bulkhead with zero torque in the rod. Shims are added to the point **X** to get the required preload in the torque rod. Tail platform, below right, must pivot to change angular position of tailplane as the torque of the rubber motor changes, yet allow tail to pop-up for the dethermaliser function. The platform is pivoted about the quarter chord of the stabiliser to minimise the aerodynamic loads on the system. The auto-rudder is a by-product of the variable incidence tailplane in that the angular motion of the platform is merely tapped to move the auto-rudder.

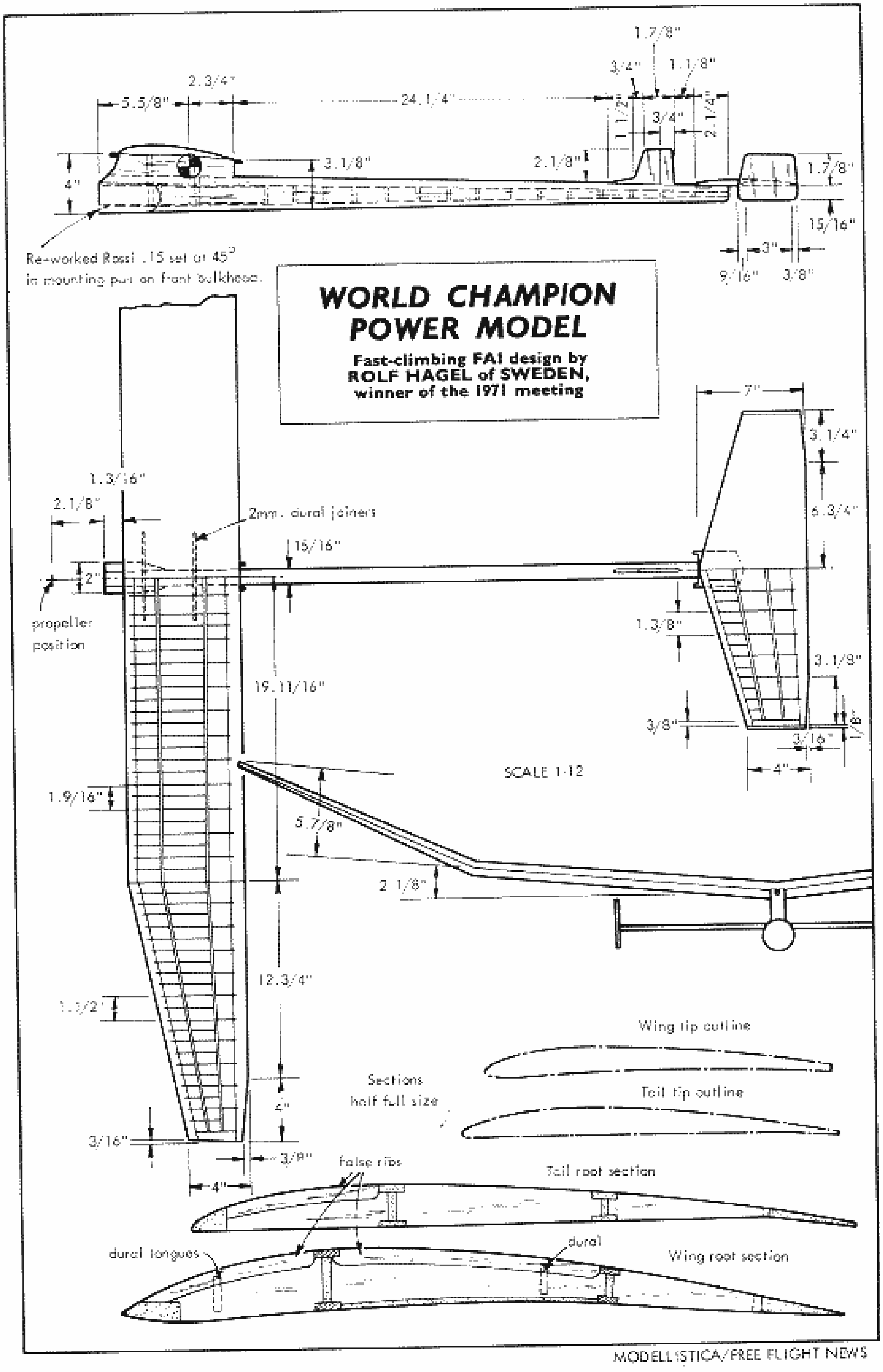




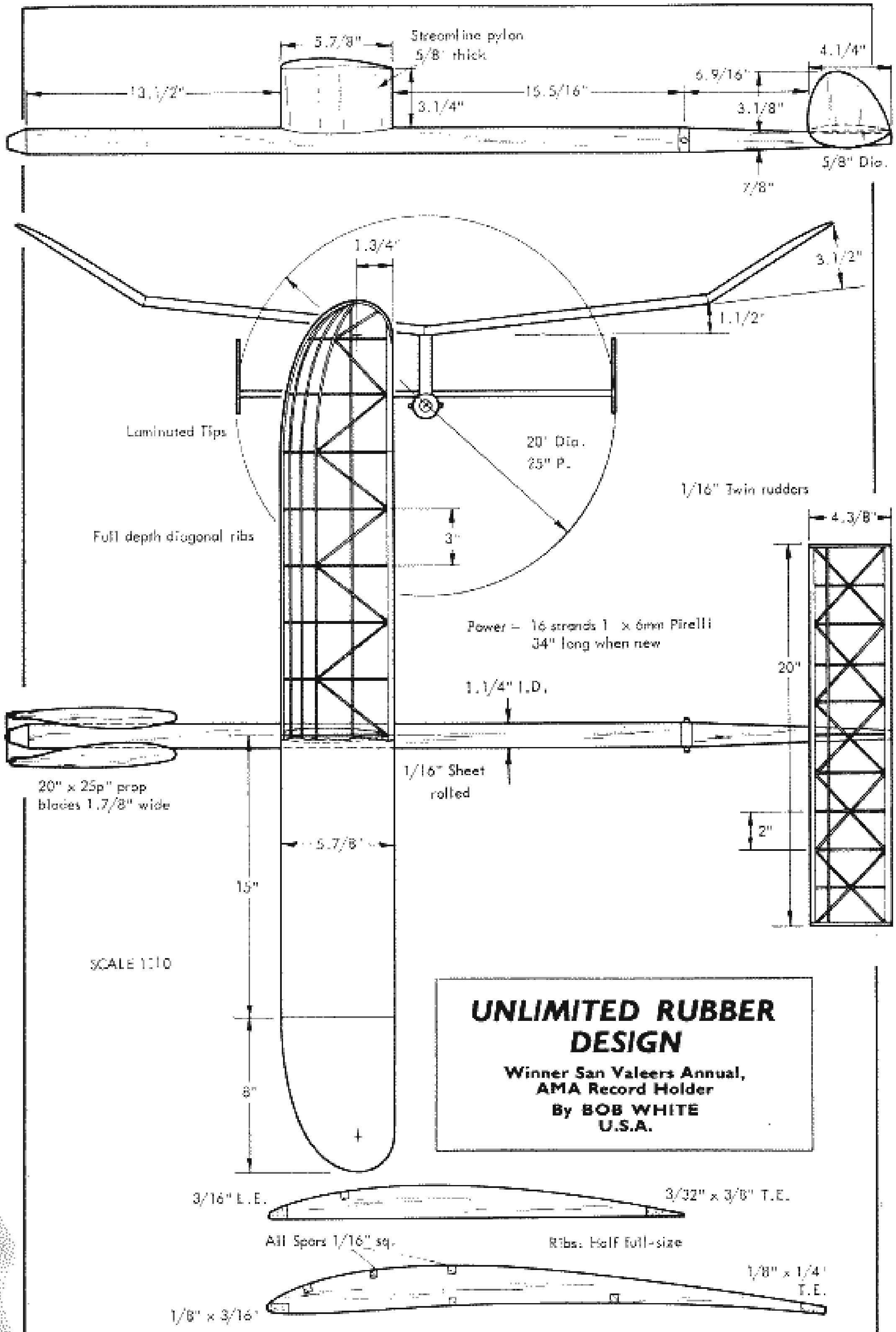
Reproduced from *FREE FLIGHT*, the NFFS Newsletter



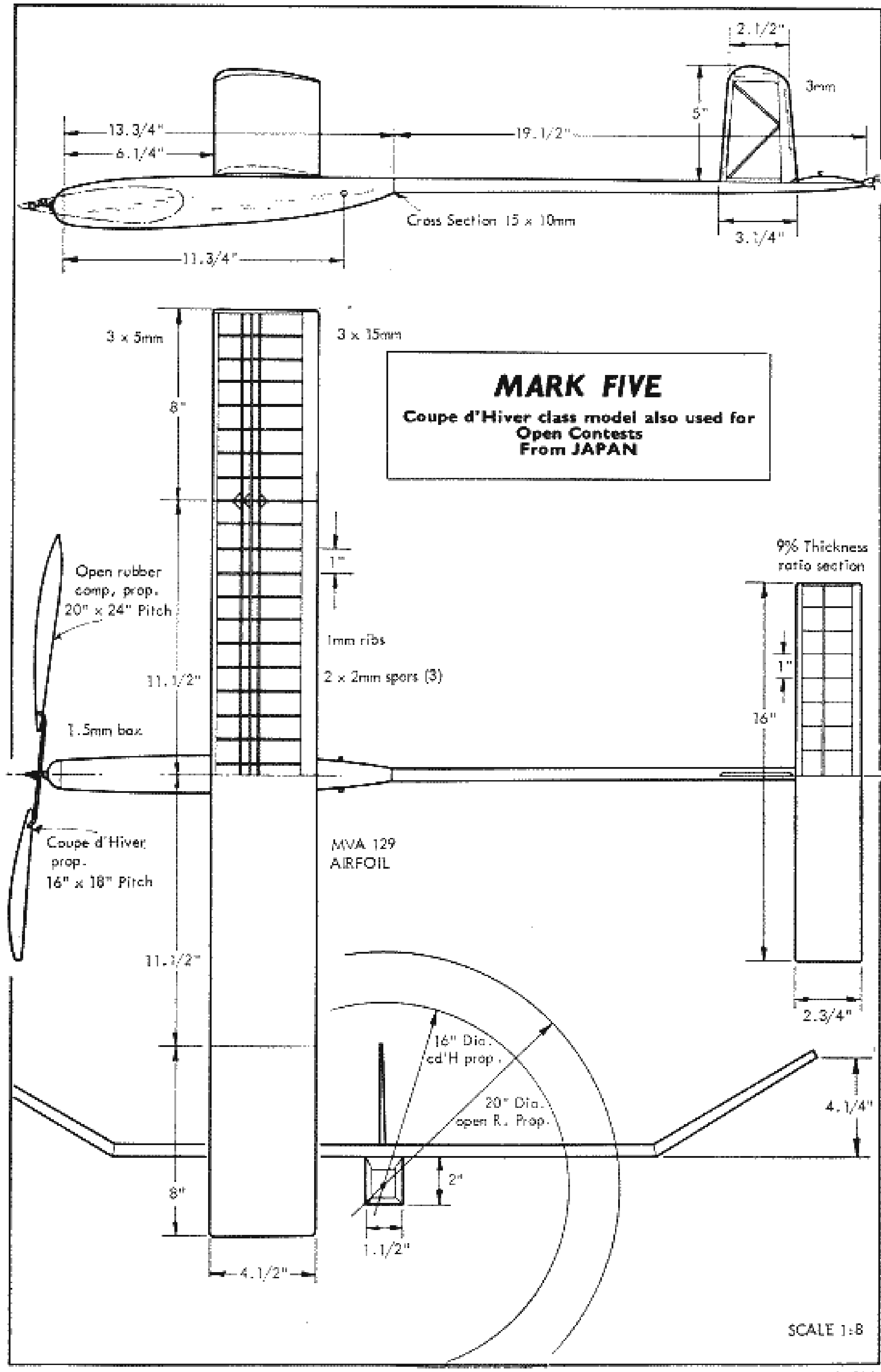
TORONTO FAI GROUP



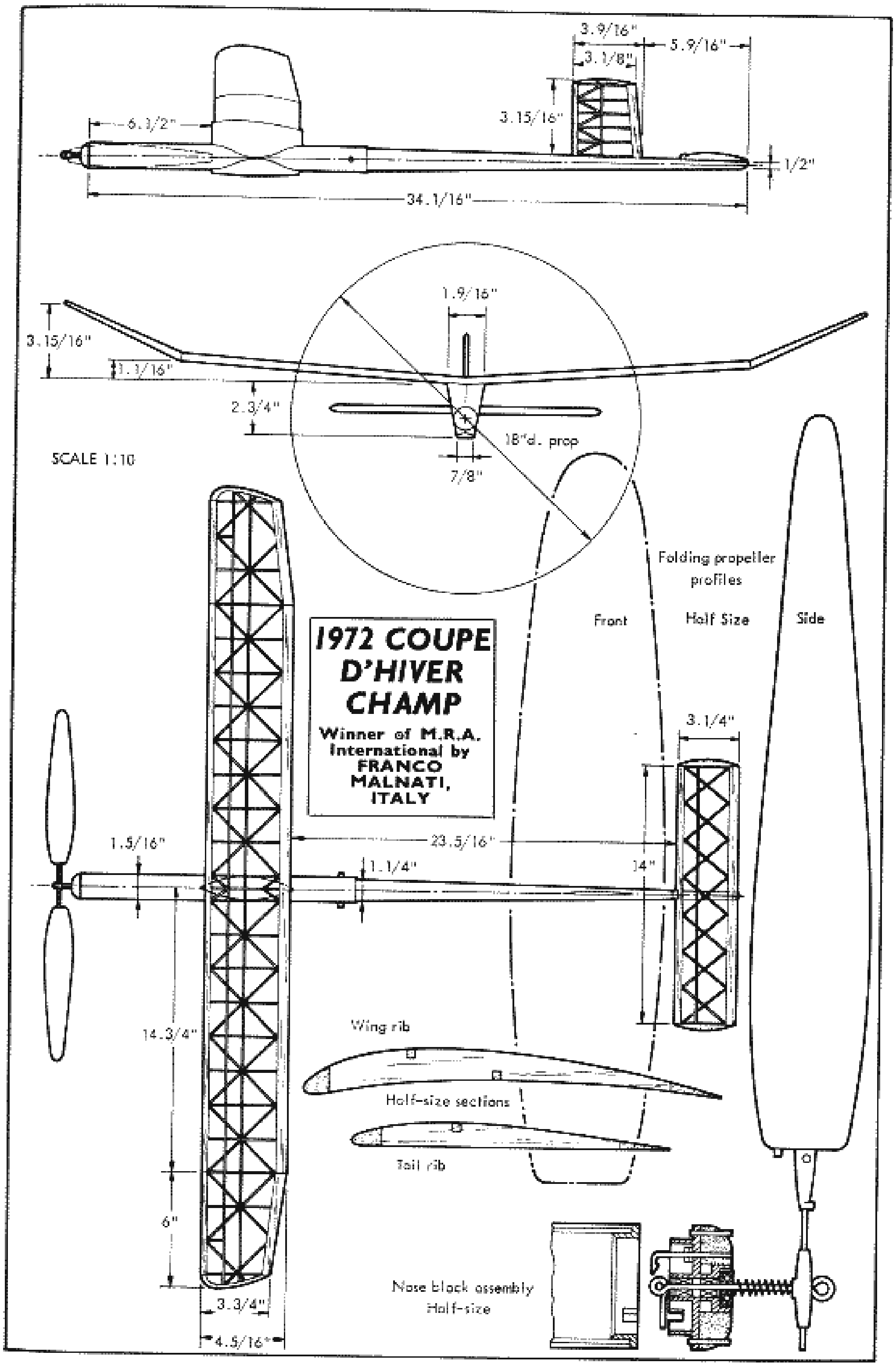
MODELLISTICA/FREE FLIGHT NEWS


5.7/8"
Streamline pylon 5/8" thick
4.1/4"
10.1/2"
15.5/16"
6.9/16"
3.1/4"
3.1/8"
5/8" Dia.
7/8"
1.3/4"
3.1/2"
1.1/2"
Laminated Tips
20" Dia.
25" P.
1/16" Twin rudders
Full depth diagonal ribs
3"
4.3/8"
Power — 16 strands 1 x 6mm Pirelli
34" long when new
20"
1.1/4" I.D.
20" x 25p" prop
blades 1.7/8" wide
1/16" Sheet
rolled
2"
5.7/8"
15"
SCALE 1:10
UNLIMITED RUBBER
DESIGN
Winner San Valeers Annual,
AMA Record Holder
By BOB WHITE
U.S.A.
8"
3/16" L.E.
3/32" x 3/8" T.E.
All Spars 1/16" sq.
Ribs: Half full-size
1/8" x 1/4"
T.E.
1/8" x 3/16"

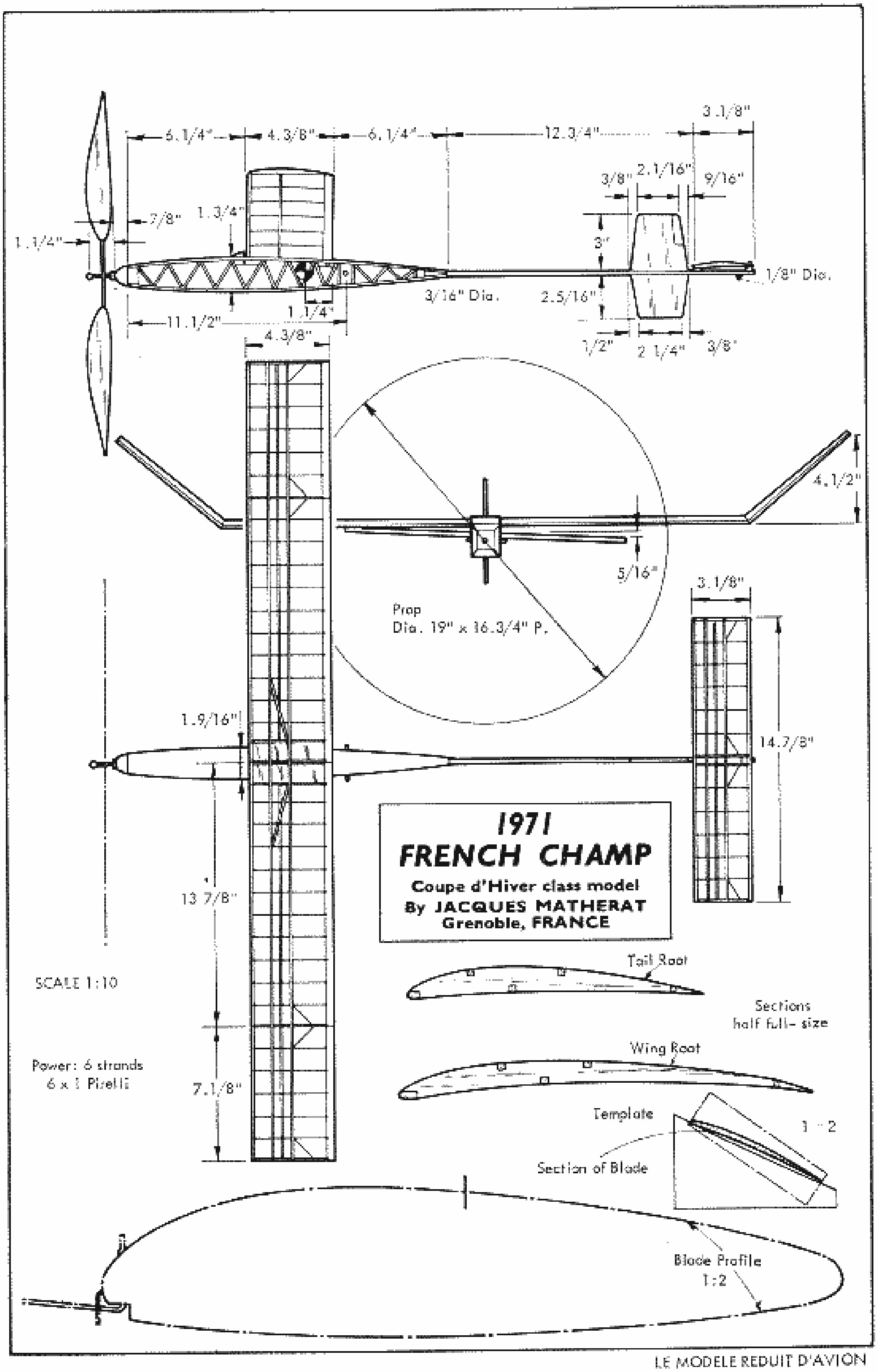
N.F.F.S. NEWS



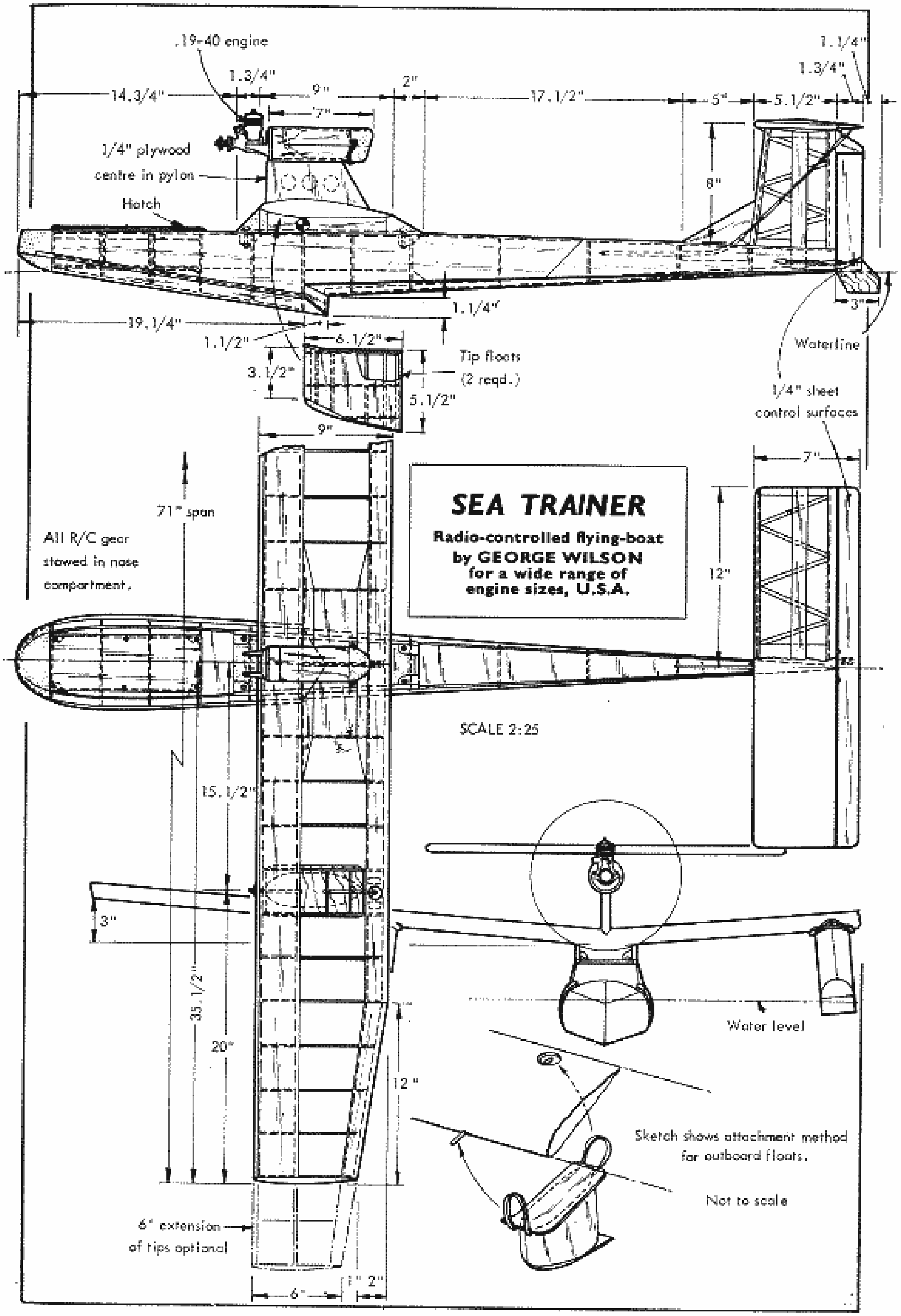
R/C TECHNIQUE, JAPAN



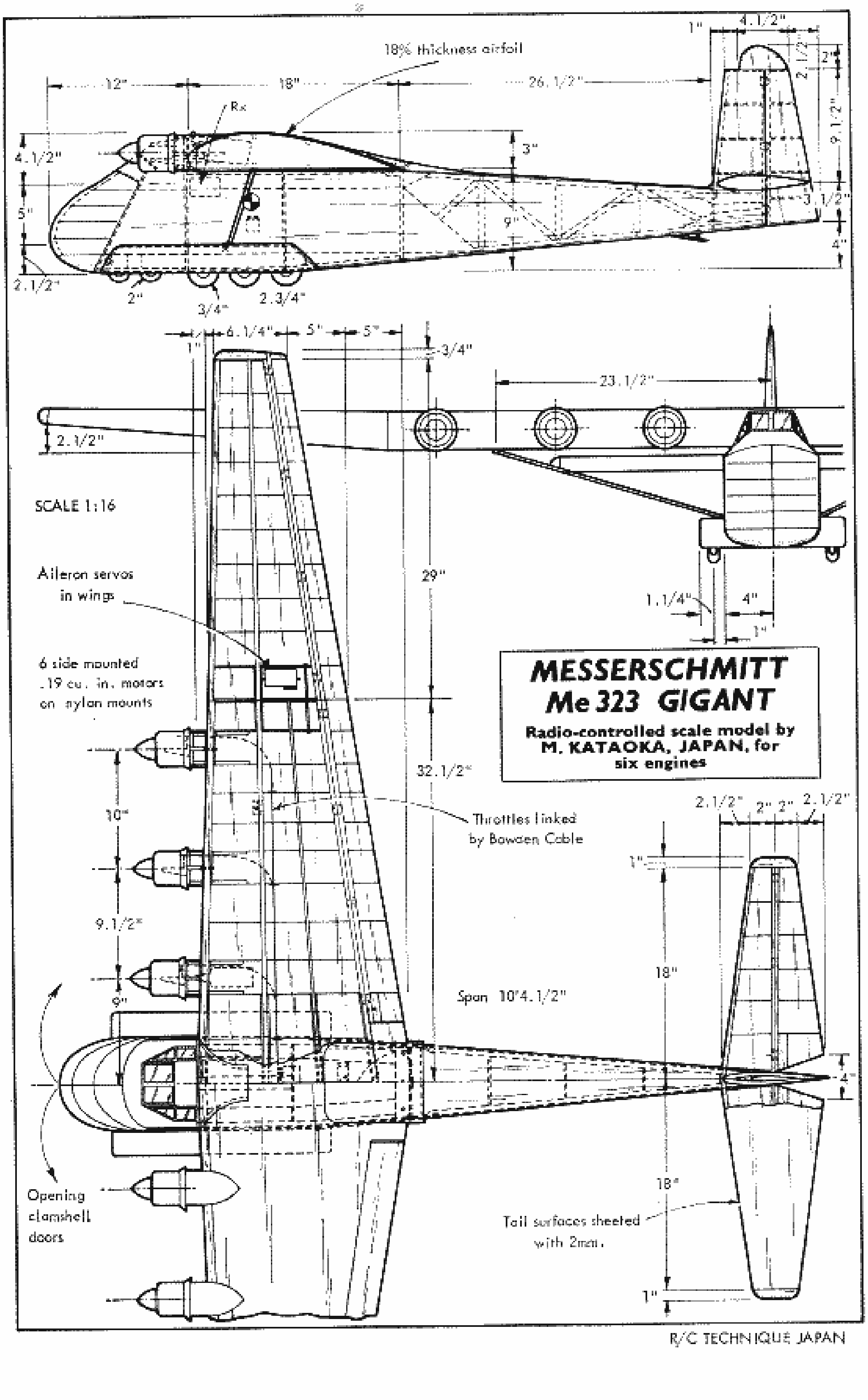
MODELLISTICA



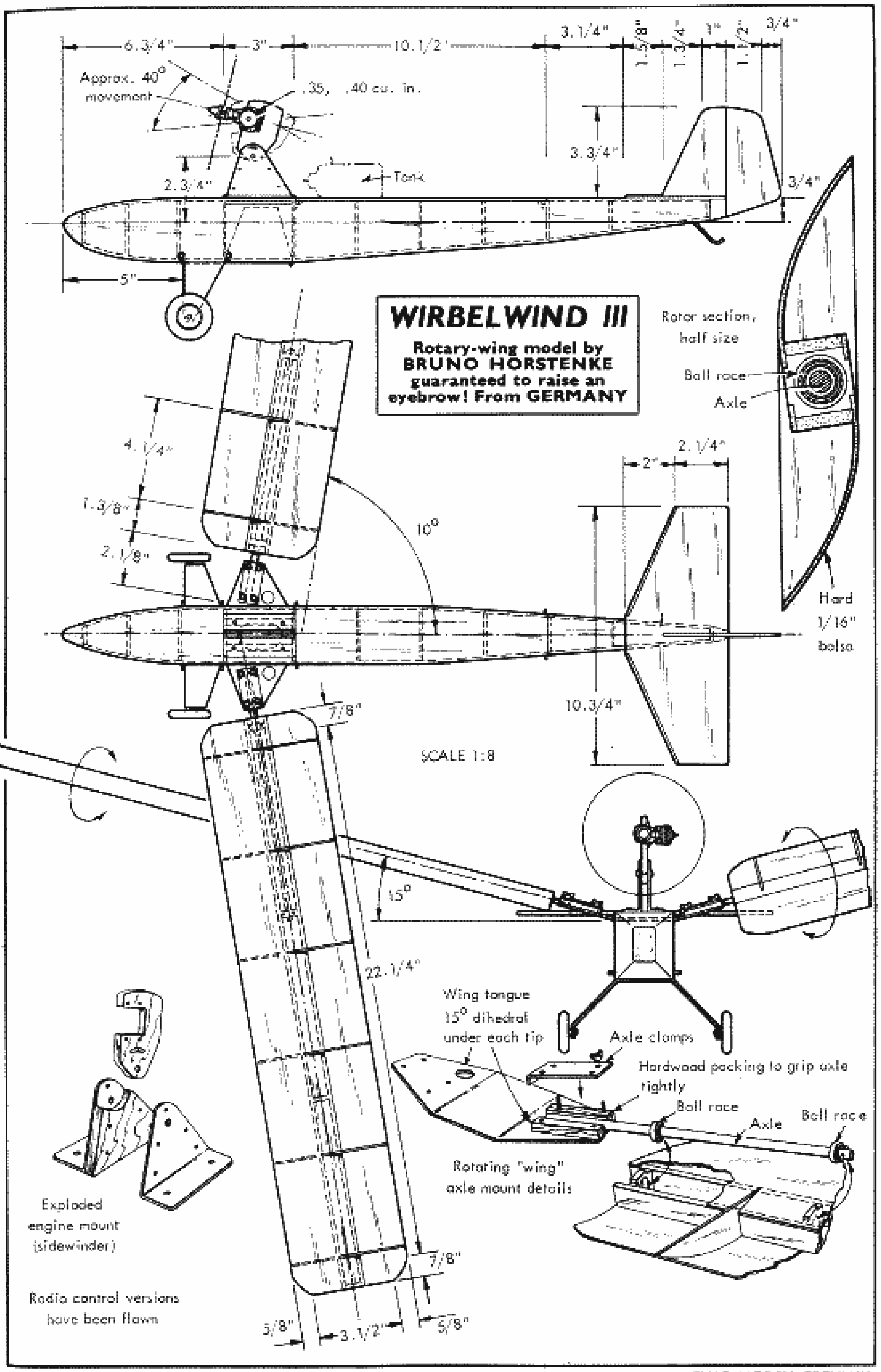
LE MODELE REDUIT D'AVION



MODEL AIRPLANE NEWS



R/C TECHNIQUE JAPAN



FLUG MODELL TECHNIK

The Technique of Magnet Flying

When hovering, the bird makes use of the slope up-current by flying into it. We do the same (if possible, on an unobstructed slope) by adjusting and launching our model into the up-current. Only in theory does the model maintain a straight flight path. In practice, as a result of various factors, the model quickly strays from course. Even the slightest deviation can cause it to crash headlong into the slope (don't forget that the wind speed has to be added to the model's own speed!).

Through its sensitivity the bird either consciously or unconsciously compensates for the slightest air movements by elegant tail and wing movements, which are hardly noticeable. The sense organ of our slope-glider is the ingeniously simple magnet control invented by Hans Gremmer of Landshut. Today this is available to all aeromodellers in its technically perfected form.

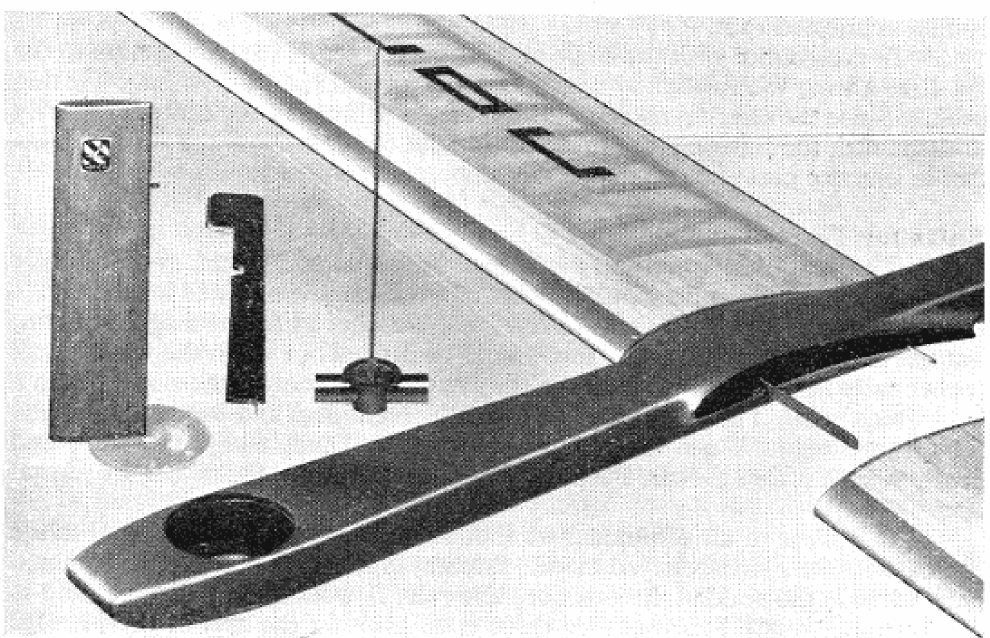
Magnet Control

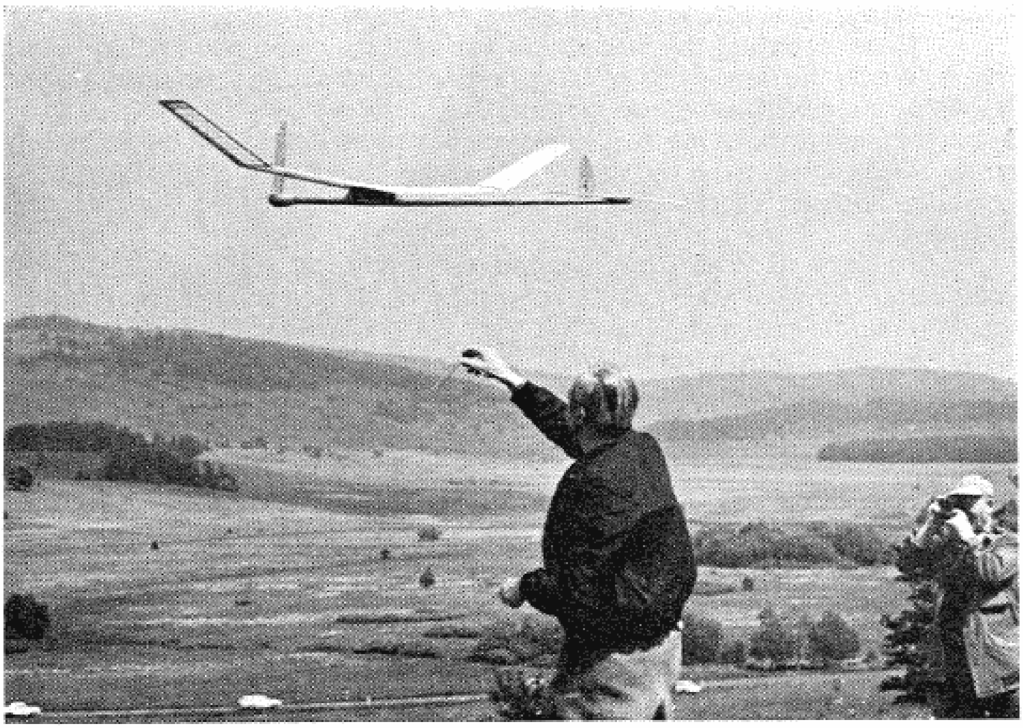
The earth is surrounded by a weak magnetic field (here, it is almost exactly 0·5 G Auss, measured in inclination). But this magnetic field is much stronger than generally believed. Ships and aircraft make use of this field with a compass to gain automatic direction readings. We use it in the same way when flying on slopes.

The 12×50/58 mm bar magnet is a large compass needle which pivots on a sapphire bearing without any friction whatsoever. This centres itself on north/south direction in the earth's magnetic field. The manually adjustable rudder is carefully set to the required angle in order to fly the model where required.

Opposite: Norica-70 on release at an Alpine site. The crisp air of high altitude, strong light and shadow coupled with the rugged snow-capped scenery made this a scene to capture the hearts of all who like the peace and solace of mountain country.

Below: Everything takes apart. Wing joiners and detachable nose steering unit on the Norica-70. The forward fin and its transparent base are rotatable in the fuselage recess for flight trim.





Herr Ludwig of Berlin launches his forward fin magnet model on the site in the high Rhone valley. Slope does not appear to be much more than 30 degrees and height about 250 ft. above the valley base.

If the model flies as planned into the slope up-currents, the rudder is maintained in a central position, resulting in a neutral steering condition. If for some reason or other the model strays from its predetermined flight path, the angle of the axis of the fuselage changes to that of the fixed magnet and the rudder connected to it.

In accordance with the angle of drift the rudder deflects in relation to the fin. Like a wing with a slightly raised flap, the fin and rudder now have a lifting profile. Since the steering mechanism is situated in front of the centre of gravity of the model, the functions are reversed to those of a rear-mounted rudder. This fact in practice causes more than a fair amount of confusion.

Rules for Test Flying

The first rule is to carry out test flights carefully and systematically keeping a cool head—otherwise, the work of weeks could be ruined in seconds.

The second rule is to effect a few hand launches using the magnet and fin, but not the rudder. If possible, this should be carried out when the wind is still (either early in the morning or late in the evening), and not on the slope, but in a field which is flat. The aim of this is to trim the flight path and balance the model for forward flight. When launching the model by hand, take a few steps and gently release it into the air. Pushing, swinging or hurling the model are mortal sins.

It is clear to all aeromodellers that straightforward flight is an absolute prerequisite for a well-behaved model. Straight flight can, of course, be trimmed only without the rudder. In practice, however, it would seem that nothing is clearly understood! Rule number three is to position the axis of the fuselage

Modellers from Bavaria in Southern Germany at the annual Colibri contest in Austria. Sunshine and soft breezes help make the exposure all the more pleasant.

and rudder precisely into wind. One cannot be too careful when trimming a model. The magnet must pivot freely during this operation. A Perspex/celluloid cap over the steering mechanism affords useful protection from the wind.

Once the model has been correctly trimmed, one need not worry about its performance in the active slope winds. If the model is launched parallel or obliquely to the slope, the speed with which it turns on to course (in seconds) is a measure of the quality with which the model has been trimmed. Ideally, the steering can be trimmed so that the model turns as quickly as possible. The most successful slope flyers use this method. Such well-trimmed models rarely stray from course.

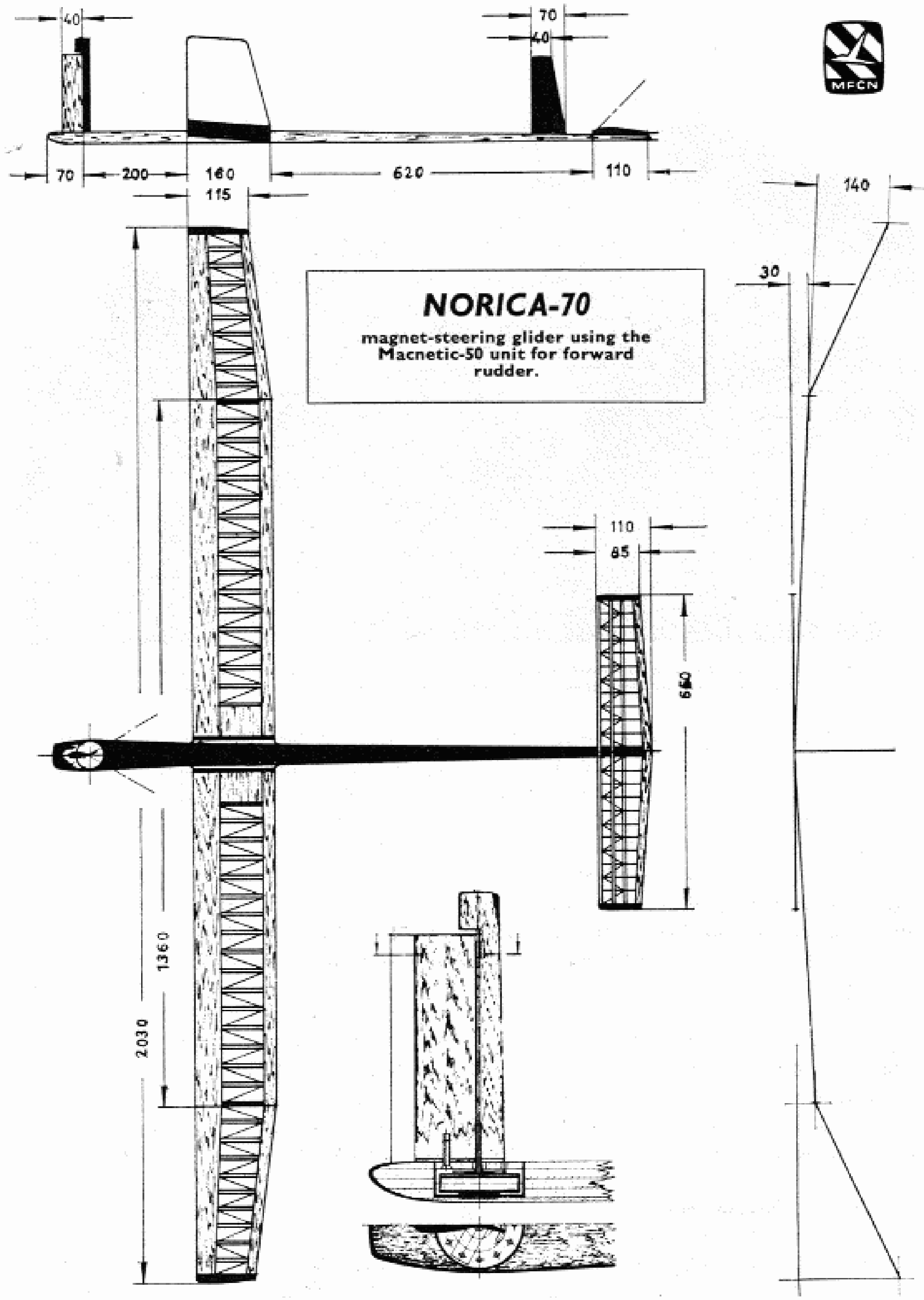
The last rule is not to release the model too abruptly—and this applies especially to the first launches. Aerobatics of any kind, especially those inducing the launching process, can be more safely undertaken at high altitudes rather than at lower ones. Over-caution can be detrimental!

If the model is well trimmed beforehand it should steer well, and take a nice course into wind. This is and will always remain a great excitement!

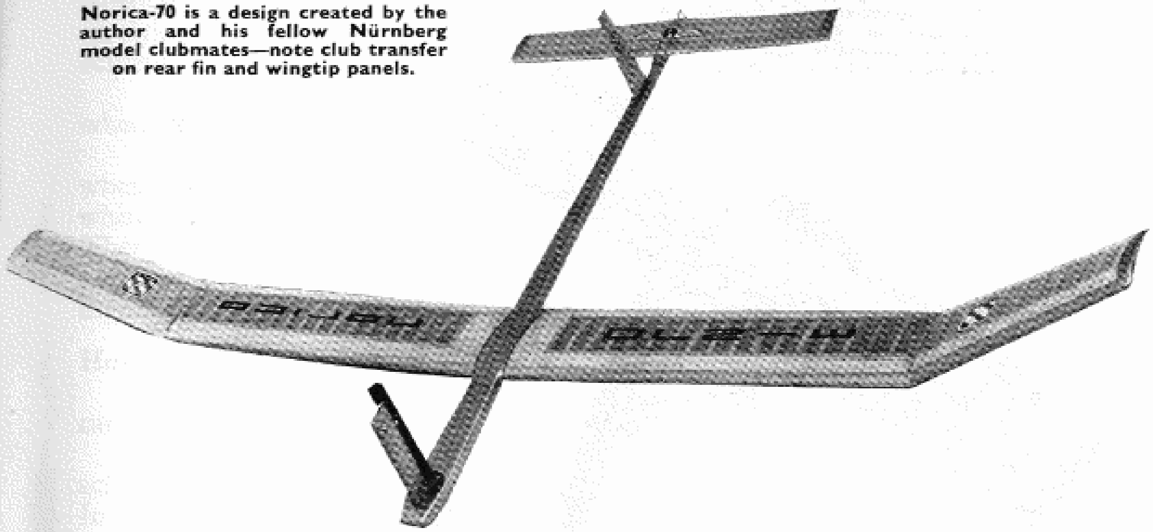
Secrets of Successful Magnet Flying

The power of the steering magnet is great, but relative and limited. This is a fact. Another important point is nicely dimensioned rudder surfaces, both of the fin itself and the rudder unit. The rudder surface and the compensating surface of the horn have to operate like a pair of scales.

For strong wind a rudder aspect ratio of 12–15 should be chosen, with correspondingly greater depth for weaker wind. It is best to have two to three well-adjusted rudders to match the wind. Correct positioning of the model in



the wind, which depends on the angle of the rudder, is a commonplace secret of successful magnet flying. A windsock, flag, or grass thrown into the air, as well as other models, can be helpful in determining the direction of the wind.



Norica-70 is a design created by the author and his fellow Nürnberg model clubmates—note club transfer on rear fin and wingtip panels.

Adjustment of the model speed to the prevailing wind speed is a real secret of successful magnet flyers. The model's airspeed depends on the profilel the combination of profiles, the dimensions, the centre of gravity, the angle of incidence, and not least of all the weight of the model.

Within certain limits, the airspeed can be varied and adjusted to the wind speed by the addition of lead to the centre of gravity, and by shifting the centre of gravity forward, simultaneously adjusting the angle of incidence.

If the model airspeed is completely unsuited to that of the wind, or the flight path is not in line with the wind—and in this a multitude of factors can play their part—the result is often a mile-long chase over fields, moors and rivers, undergrowth, slopes and grass. This sport is by no means inferior to Olympic standards. It forms muscles, improves fitness, and especially important, creates the desire to do better next time!

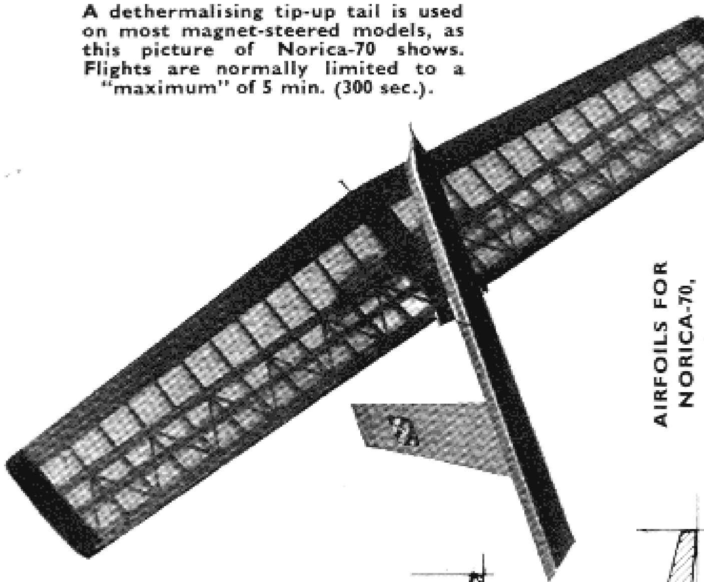
Important Techniques

The airspeed of the model, the prevailing wind speed, the slope conditions, the path of flight with possible obstacles like fog, wooded sides, different wind speeds and directions, a few hundred metres from and over the launching area, all necessitate different flying techniques in order to be able to carry out a full 5 minutes' test flight. Further reasons for different flight tactics include disappearance from view, especially in misty weather or when the model's airspeed is high. The model must also be spotted and located. We also want to avoid long, nerve-racking searches for the model, loss or cumbersome and exhausting walks over steep slopes and hilly terrain to retrieve it.

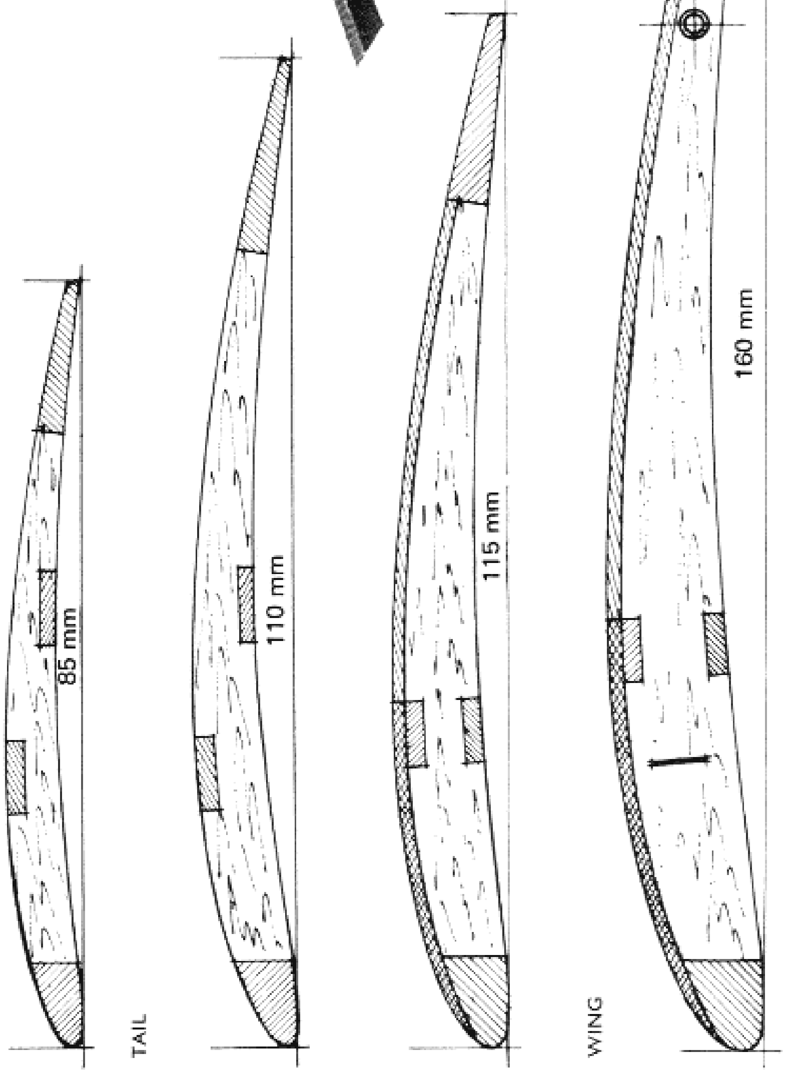
Furthermore, depending on the nature of the ground, thermals and up-wind currents are small in area, or border on to down-wind currents, whirlwinds, windstill areas or other passive conditions. Here is a brief description of the main techniques possible in practice: straight flight, hovering, zig-zag or meandering flight, and especially straight flight with occasional turns, as well as circling into wind.

Straight Flight

Due to the simple, uncomplicated and safe working of the normal head



A dethermalising tip-up tail is used on most magnet-steered models, as this picture of Norica-70 shows. Flights are normally limited to a "maximum" of 5 min. (300 sec.).



AIRFOILS FOR NORICA-70, actual size

steering, the straight flight is used for more than 70% of all launches. Depending on flying conditions and the use of light wind models, a small number of these achieve ideal hovering conditions.

Generally, in medium to strong wind, good to best times can be achieved when the model flies in a straight line.

As a rule, the airspeed of the model should exceed the speed of the wind when it is launched, by 1–4 m/sec. In this way, the model flies quickly from the whirly, dangerous launching position into the laminar upcurrents of the slope. There it either slows down due to higher wind speed or hovers if it is correctly positioned. On large unobstructed slopes, this is the safest way of effecting test flights. See Swiss journal *Aero Revue* No. 6/1969.

Hovering

Hovering is the form of flying most similar to that of a bird, and can be carried out as described previously in straight flight into wind.

Furthermore, hovering on small slopes and at low wind speeds can be achieved by using light-wind models especially designed for this form of gliding. In this context, I mention simple steering devices with almost frictionless connecting-rod steering linkages to the rear rudder unit.

Zig-Zag or Meandering Flight

During the past few years, the zig-zag or meandering flight has been propagated particularly by the Italians. This can be done either independently of the magnet-control device by means of a fuse, a mechanical or electronic timer effecting period rudder movements, by locking the rudder mechanically, or as in the case of the Italians, by electronic operating methods. This activates the rudder. The basic requirement for this system, which in principle is amazingly simple, is the faultless operation of the steering, especially in the more critical phases of a return meandering flight.

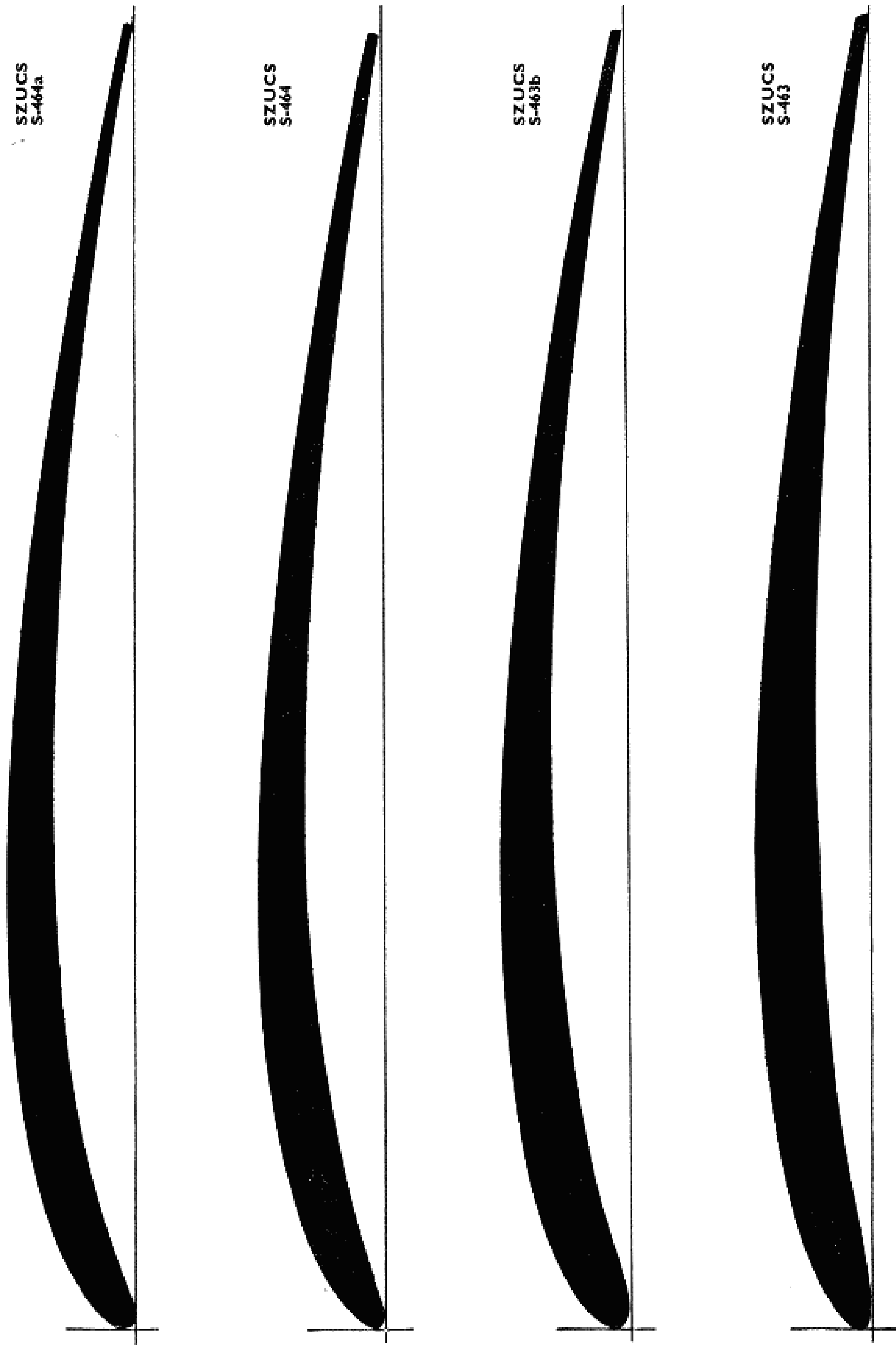
There is, however, a considerable disadvantage in this system. The model remains near to the launching spot for a long time, and is, therefore, exposed to wind eddies which are particularly dangerous during the first few metres.

Straight Flight with Programmed Turns

After the straight and hovering flights, the system of programmed turning flights is the best known and safest one. In straight flight the model flies relatively quickly through the dangerous wind zones into the up-currents on the slope. Before flying into these, the model is turned by flipping the rudder over at 25°. This can be done either by using a double fuse at the horn, a Tatone timeswitch with steering cam of the Weichselfelder type, or a multi-sequence electronic timer with a fuse.

When the model has returned to the edge of the slope after completing a full turn, it is customary practice to allow it to fly through the up-current of the slope in straight flight before carrying out the next turn. At a safe distance from the slope and not too great wind speeds it is, however, possible to fly several turns in succession.

The flight phases of a programmed turn are as follows: the magnet-controlled model flies away from the launching spot straight into the up-current zone. The rudder is locked to the right by a rubber band with a fuse or timer. This is how to carry out a left-hand turn into wind. The model then flies transversely and subsequently with the wind in the direction of the slope itself. Before turning into wind when the model is at 30° to the direction of the wind,



AIRFOILS FOR SOLID BALSA GLIDERS

the magnet operates the rudder, *i.e.* swings from its locked position of 25° to the full 40° of the magnet control device.

This full swing of the rudder to the right causes a sharp turn to the left on the return flight. In the meantime, the lock has been fully released by the second fuse at the horn, or by the timer. From its limited angle of 15° the steering device can now become effective again over the full 80°. This final movement ends the turn, and the model turns on to the programmed straight-flight path. This system was perfected by Weichselfelder. In 300 seconds he can carry out 2–6 turns. Only the most devilish of circumstances can prevent a full test flying sequence being carried out.

Circling into Wind

There is no doubt that this requires tactical, technical and flying skill of a high order. These high requirements are made essential by a complicated system which outwardly appears simple. When circling into wind in order to carry out a left turn the fin is inserted into its PVC sleeve at an angle of approximately 10° to the left, which is about 6 mm movement of the leading edge of the fin. Looking at the profile of the fin only, during normal air flow, it is at a slight angle of incidence to the fuselage axis and, therefore, to the direction of air flow. This results in lift to the left. The steering rudder is positioned into wind as usual.

However, we do not launch the model into the currents of the slope. For a turn to the left later, we launch it to the right almost parallel or slightly oblique to the slope. During the launch the rudder deflects fully to the right. This position effects a left turn which is supported by the lift created by the fin positioned obliquely to the fuselage axis.

The model turns relatively quickly to the left. When the fuselage axis is at an angle of 45° the rudder frees itself and the model flies on a straight course. If the model has turned fully and the fuselage axis is positioned straight into the air current, the rudder is in a neutral position. However, the fin, which is slightly to the left, gives rise to lift to the left.

The left-hand turn is now continued against the up-currents at a lower speed, since in this phase of the flight the lift created by the fin, which is directed to the left, compensates for the force to the right as a result of the rudder being deflected to the left. This means that the second part of the left-hand turn will be relatively prolonged. Consequently, the lift created by the fin positioned to the left gains the upper hand over rudder movements to the right and the model turns with the wind towards the slope. The rudder remains deflected to the left

LASZLO SZUCS S-464a

X	0	2.5	5	10	20	30	40	50	60	70	80	90	100
Upper	0.84	3.76	5.60	7.20	8.60	9.80	9.65	9.32	7.96	6.53	4.85	3.98	0.75
Lower	0.84	0.30	1.48	2.96	4.90	5.84	6.25	6.10	5.50	4.45	3.26	1.78	0.00

LASZLO SZUCS S-464

X	0	2.5	5	10	20	30	40	50	60	70	80	90	100
Upper	0.85	3.65	5.15	6.90	8.90	9.50	9.30	8.70	7.70	6.30	4.75	2.80	0.70
Lower	0.85	0.20	1.00	2.30	3.95	5.35	6.35	5.75	5.15	4.20	3.05	1.65	0.00

LASZLO SZUCS S-463b

X	0	2.5	5	10	20	30	40	50	60	70	80	90	100
Upper	1.20	4.50	5.60	7.30	9.05	9.75	9.75	8.60	8.05	6.75	5.05	3.10	0.80
Lower	1.20	0.20	0.85	1.70	4.20	5.30	5.80	5.75	5.30	4.45	3.25	1.80	0.00

LASZLO SZUCS S-463

X	0	2.5	5	10	20	30	40	50	60	70	80	90	100
Upper	0.79	3.45	4.63	6.20	7.90	8.68	8.48	8.25	7.40	6.20	4.67	2.68	0.74
Lower	0.79	0.00	3.25	1.13	2.66	3.33	4.65	3.74	3.80	3.26	2.26	1.26	0.00

even when flying towards the slope, and makes the left-hand turn less sharp. This is a critical phase of the flight. Until the turn is completed and the fuselage axis is at about 30° to the left the magnet moves and the rudder moves fully from the left to the right.

Since the lift created by the rudder and fin to the left are combined, this is the right moment to effect a sharp left-hand turn parallel to the slope and then away from it. The model turns parallel to the slope and flies to the left just as it does when launched.

Alternate flying in a large semicircle at 90° into and 90° away from the wind, and subsequently flying in a small semicircle at 90° into and 90° away from the wind is, therefore, characteristic of circling into the wind. Here I would mention that fast-flying models have a tendency to short-cut sharp turns. It is best, therefore, to trim the model accordingly. Due to minimal drift away from the slope the model remains almost continually in the up-current when circling against the wind. With this flight tactic it is dangerous to allow side drift or drift over the launching spot or the top of the mountain.

It should be clear that circling into wind should only be carried out by really experienced flyers when the wind speeds are low and up to 4 metres per second.

THE MAGNETIC

Balancing

A carefully balanced steering magnet, both statically and dynamically, is an absolute prerequisite for a well-functioning magnet steering device. After glueing a 2 mm shaft into the cavity of an aluminium frame with Loctite-Green glue, static balancing is carried out on an absolutely flat and level surface. The magnet must then be adjusted in the frame so that it takes a bearing without oscillating irrespective of the position in which it is placed. Dynamic balancing is best carried out on one's fingernail, since this gives a sensitive touch. Irregularities of the magnet's operation can easily be detected.

Re-magnetising the Magnet

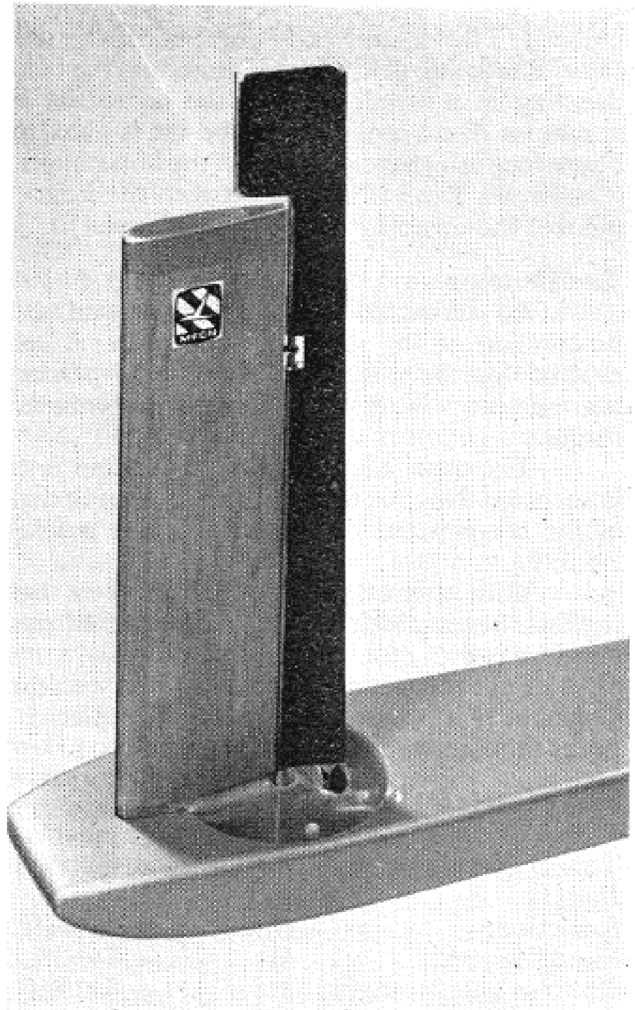
Long storage, movement in transit, etc., cause the magnet to lose strength. Its strength can be restored by short impulses of 3/4,000 A/cm. For this I would refer you to your nearest car repair or electrical service shop (Bosch-Service). There you will find the right equipment to carry out this operation in minutes, and it will not cost you too much!

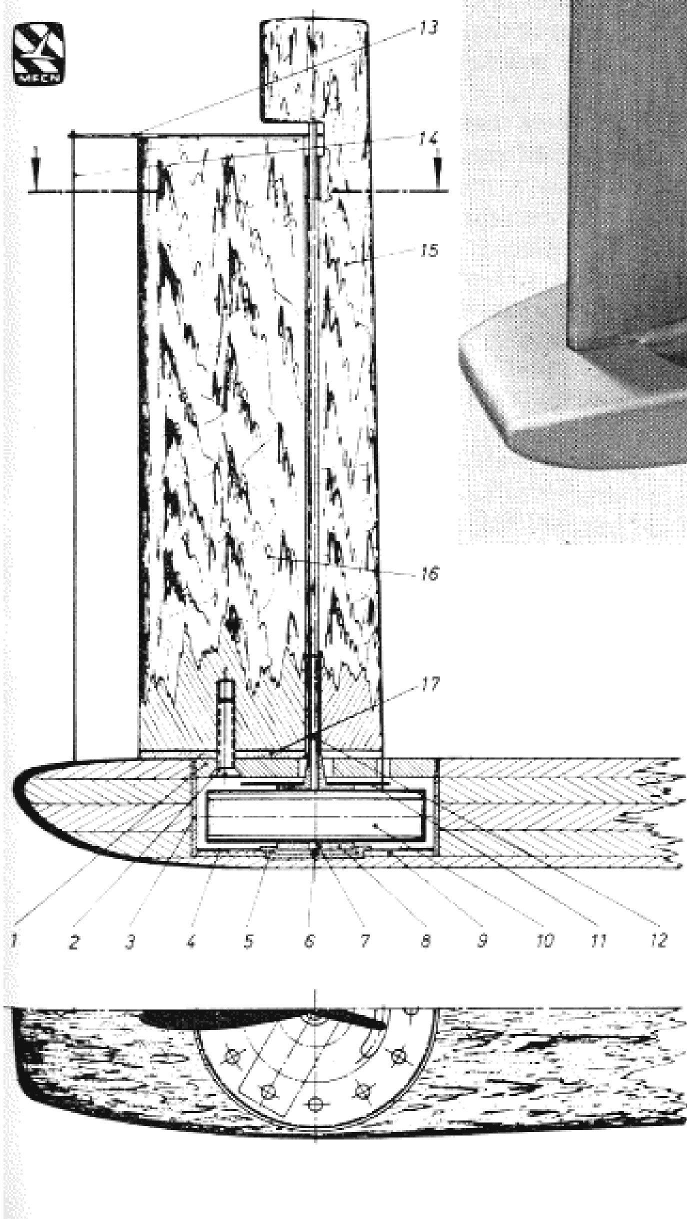
Binding Agent

After careful balancing, Loctite-Green is squeezed into the gap between the frame and the magnet. As Loctite hardens only between metal surfaces, the surplus can be wiped away effortlessly. This is one of its most important advantages. It is interesting to note that Loctite is not a glue in the true sense, but a binding medium. Apart from Loctite I can particularly recommend OMI-Typ 150-green L, manufactured by Omi-Technik GmbH, 8 München 50.

Damping

In order to achieve smooth flight the strong oscillating movements of the magnet have to be damped. This can be done by applying the physical laws of electro-magnetic induction. When the steering magnet with an energy density factor of B moves over a metal conductor at a speed v—which is a 4 mm aluminium disc glued into the bottom of the frame—an electro-magnetic field is





The Macnetic-50 steering unit in cross-section at left; part numbers relate to the original kit instructions for assembly. These magnetic units are marketed in Germany and Switzerland. Cost about £3·50. The magnet itself part number 10 is 12 mm in diameter, 50 mm long.

induced. This creates eddy currents in the disc. These eddy currents in turn cause a magnetic field which counteracts the field of the steering magnet, thereby damping in a simple manner the oscillating movements. The $0{\cdot}4 \times 0{\cdot}57$ aluminimum disc supplied with the kit is glued under the bottom of the model. Numerous tests have shown that the dimensions of this disc are the most suitable (Coulomb's Law: If the slit between the magnet and the frame is doubled, this reduces the damping effect by one-quarter).

The Bearing

An almost frictionless bearing is of utmost importance to the correct functioning of the steering mechanism. A completely new system has been evolved for the Macnetic: a precision bearing is glued into the aluminium bearing seat, whereas the sapphire is positioned at the top of the frame of the magnet.

The main advantage of this system is that the distance, as well as the influencing dynamic forces occurring during flight, between the centre of gravity of the magnet and the position of the bearing is reduced to a minimum of 7·5 mm.

With this system, a 1·58 mm steel ball moves on a highly polished sapphire bearing which has a diameter of 4·8 mm. The depth of the cavity in the sapphire is 0·45 mm.

Following rough landings, it is recommended to have a look at the sapphire. If it is damaged, it must be replaced. A new sapphire can be quickly glued in place with Uhu-Hart glue.

The Steering Magnet

The only magnet size which is available for the Macnetic is 12×50 mm. This magnet is cut and the edge round-finished.

Data:

Induction:	B	= 9,000/10,000 Gauss (= $10^{-8}\,Vs/m^2$)
Field strength:	H	= 440/380 A/m (79·6 A/cm = 1 Oersted)
Coercive field strength:	Hc	= 560/460 A/cm
Energy factor:	BH	= 3·5/4·6 m Ws/cm^3
Residual magnetism:	Br	= 1,100/12,700 Gauss
Material:	Al-Ni-Co	= 8% Al, 15% Ni, 3% Co; different additives
Magnetising:	I	= Induction B $\times$ field strength H
Magnetic moment:	M	= Magnetising I $\times$ volume V

In this particular context, the earth's magnetic field is of great significance. In West Germany it is almost 0·5 Gauss, measured at 67° inclination. Directional torque D (p/cm per degree of angle) is a direct measure of the Macnetic's steering power. When only minimal steering control is applied it is practically proportional to the earth's magnetic field and the magnetic moment of the magnet.

Control Disc

In order to set the differential angle between the magnet and rudder a disc (part 11) is glued on to the frame with Uhu-Plus glue. The notching is registered by a piece of 26 s.w.g. control-line wire.

Plexi Disc

By means of a Perspex disc over the mechanism we can observe the movement of the magnet needle. Due to the design of the 80° track in which the rudder moves, the air forces are reduced to a minimum. Aerodynamically, this is an ideal solution. There are four 3 mm holes into which a pin can be inserted to adjust the differential angle.

The Fixed Fin

Good quality quarter-grain balsa wood is used for the fin. For the double turbulence groove at the leading edge, three pieces of 2×8 mm pine are used, which are glued together, then shaped with the "gutter" at the front.

The fin is carefully profiled by glueing plywood rib profiles on to both ends at top and bottom. This way, a nice fin profile is obtained, which facilitates highly effective steering conditions.

Lightweight Japanese paper is put on to the fin with Glutofix, brushed with water, and after drying a few coats of dope are applied. One can also use Rocacell hard polystyrene for the fin. This is a rough/fine texture material.

Nylon Screw

The fin is screwed to the Perspex cover by means of a nylon screw (part 2) and this is secured with Uhu-Plus glue at the top and bottom. The following is interesting. If the screw was of metal, the circular movement of the magnet would induce an electro-magnetic field in it. In turn this would affect the magnet itself. The nylon screw avoids this.

The Rudder

A $3 \times 0{\cdot}5$ mm PVC tube (made by Graupner) is mounted in 3 mm quarter grain balsa with Uhu-Plus. The compensating horn is reinforced with 1·5 mm balsa. I do recommend that these dimensions are adhered to, for they constitute the findings of several tests.

What has been mentioned above about a rough/fine fin texture, applies especially to the rudder. Only in this way can one obtain a really efficient steering mechanism. Again I recommend the use of Rocacell for the rudder blade.

Spitzer's (MFCN) method of positioning the upper hinge, not at the horn, but 40 mm lower down, has proved to be particularly suitable. The strength of the horn is greatly improved, and fewer repairs are necessary.

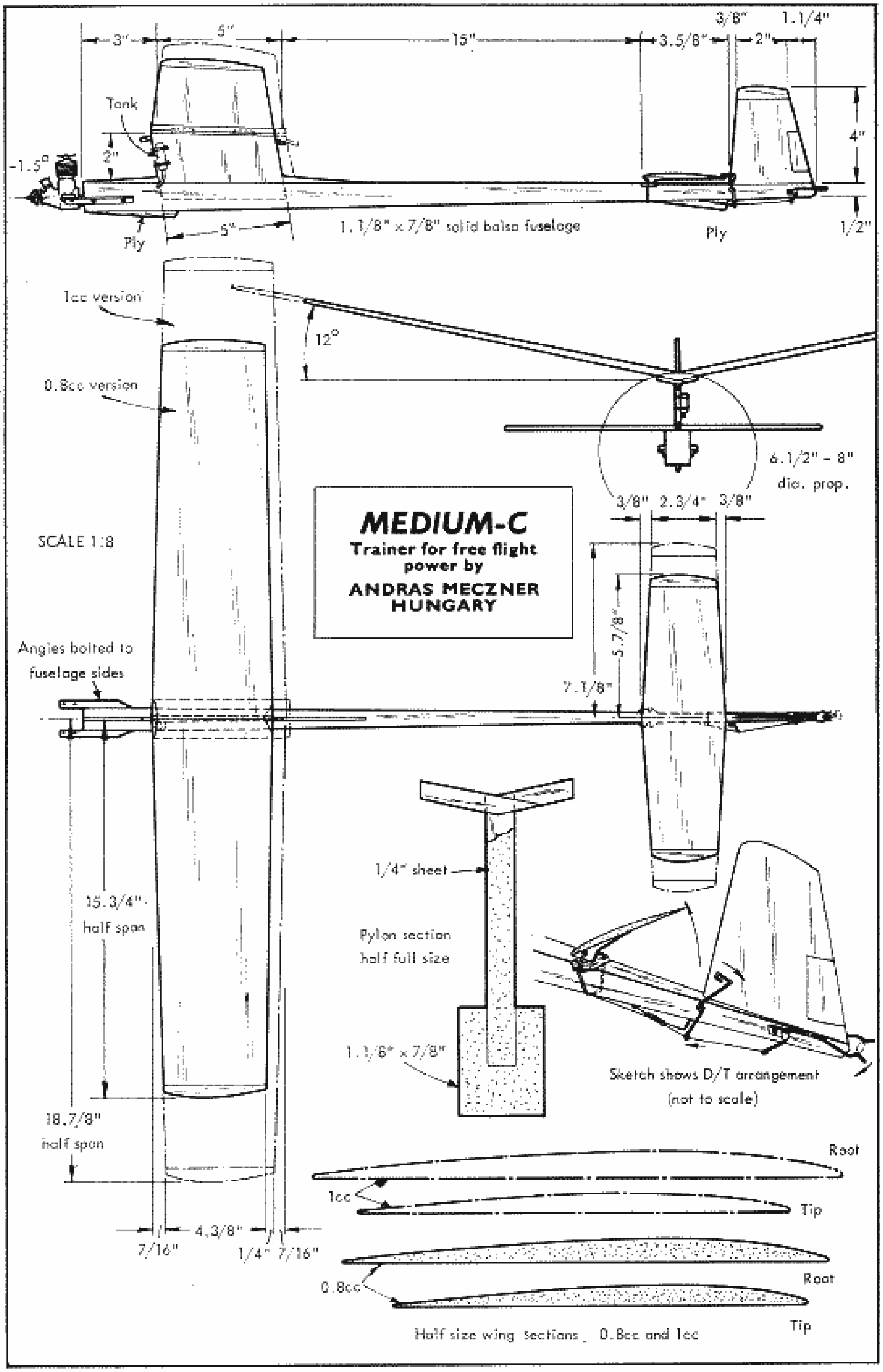
Turbulator

It would be ideal if air flow near the steering unit profile was the same as that near the wing or fuselage. Unfortunately, this is far from being so. To achieve this ideal situation, the ratio of inactive and friction forces should be identical to each other. Differences are expressed by Reynolds Number:

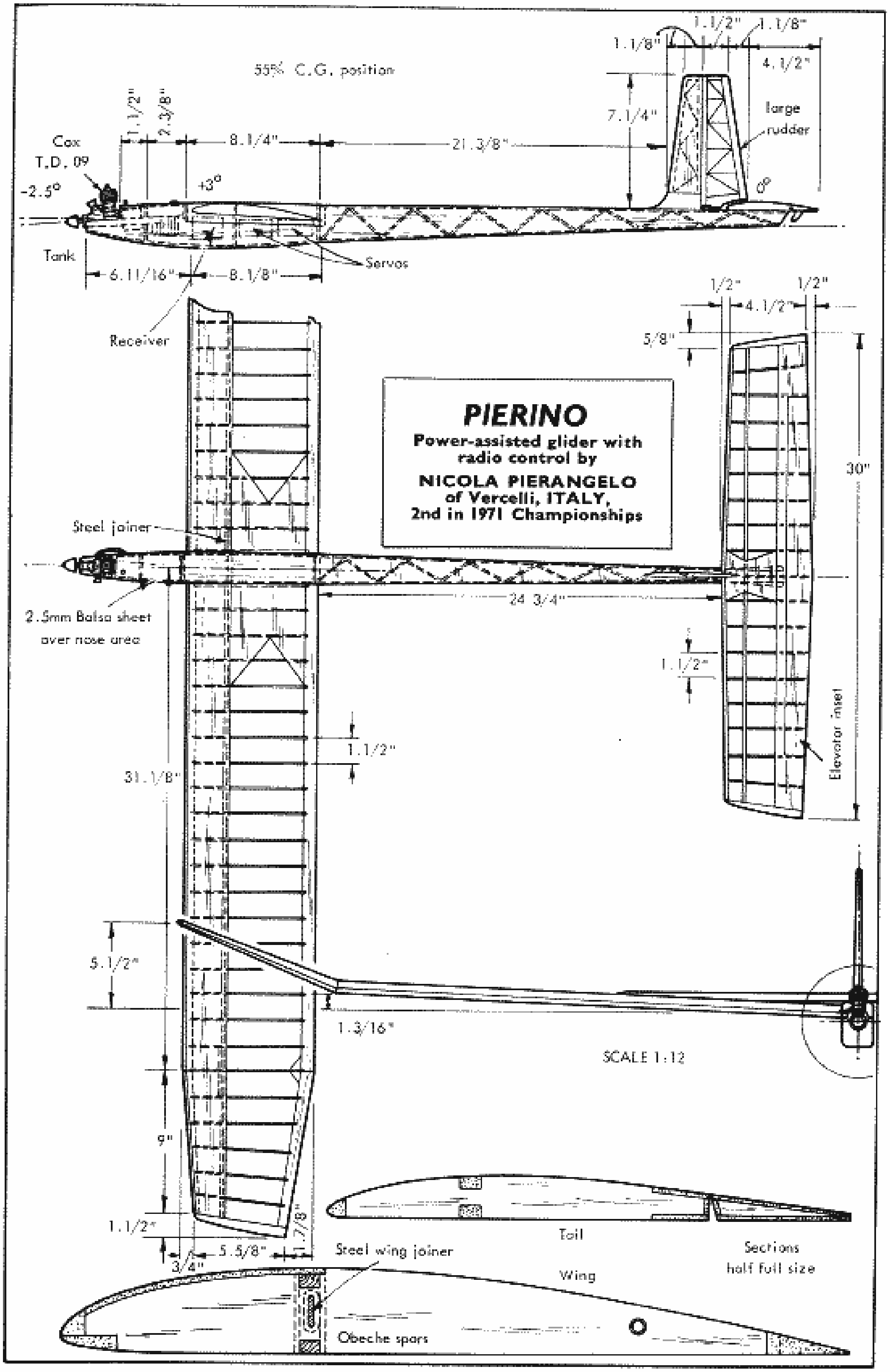
$$\text{Re-Steering} = \frac{4\ (\text{m/sec}) \times 55\ (\text{mm})}{0{\cdot}000015} \quad \left(\frac{\text{Speed} \times \text{profile depth}}{\text{Cinemat. viscosity of air at 16G}} \right)$$

$$\text{Re-Area} = \frac{4\ (\text{m/sec}) \times 150\ (\text{mm})}{0{\cdot}000015}$$

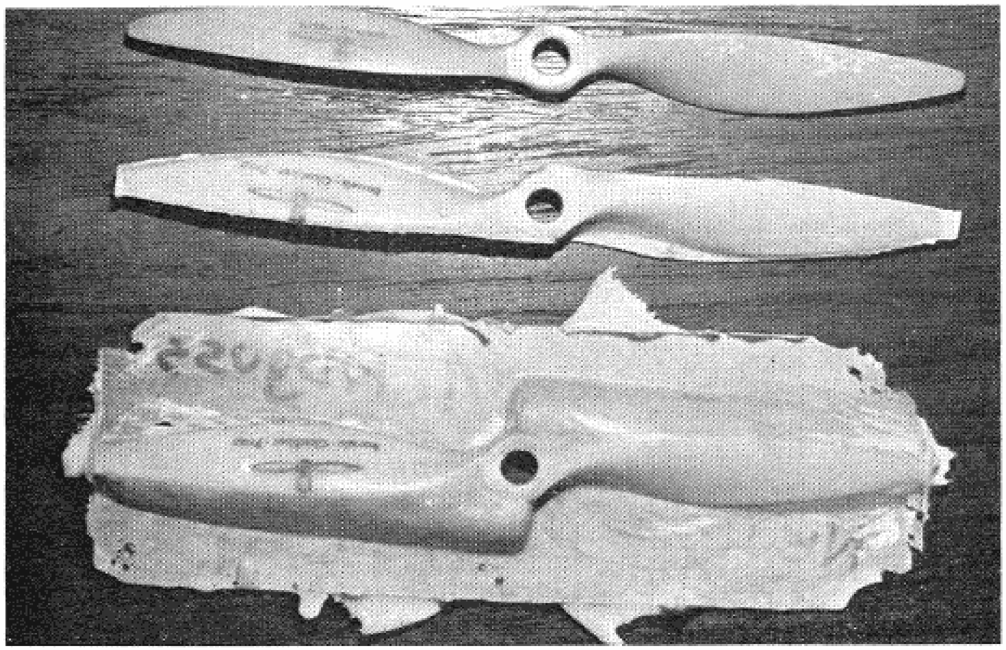
The Re Number of the steering is only one-third of the area. This means that air flow conditions are very critical at this stage, for correct steering function. For this reason I recommend the use of a turbulator, which is 14 mm ahead of the leading edge. An 0·6 mm thick rubber cord has also proved very suitable for this. See part 14 in the diagram, which is half size.


3"
5"
15"
3.5/8"
3/8"
2"
1.1/4"
Tank
2"
-1.5°
4"
Ply
5"
1.1/8" x 7/8" solid balsa fuselage
Ply
1/2"
1cc version
12°
0.8cc version
6.1/2" - 8"
dia. prop.
3/8"
2.3/4"
3/8"
SCALE 1:8
MEDIUM-C
Trainer for free flight
power by
ANDRAS MECZNER
HUNGARY
5.7/8"
7.1/8"
Angles bolted to
fuselage sides
1/4" sheet
15.3/4"
half span
Pylon section
half full size
1.1/8" x 7/8"
Sketch shows D/T arrangement
(not to scale)
18.7/8"
half span
Root
1cc
Tip
4.3/8"
7/16"
1/4"
7/16"
Root
0.8cc
Tip
Half size wing sections 0.8cc and 1cc

MODELLEZES



MODELLISTICA



Three stages of moulding: from bottom upwards, a rough, with flash from the mould; centre, flash cut away by saw; top, finished and ready for use.

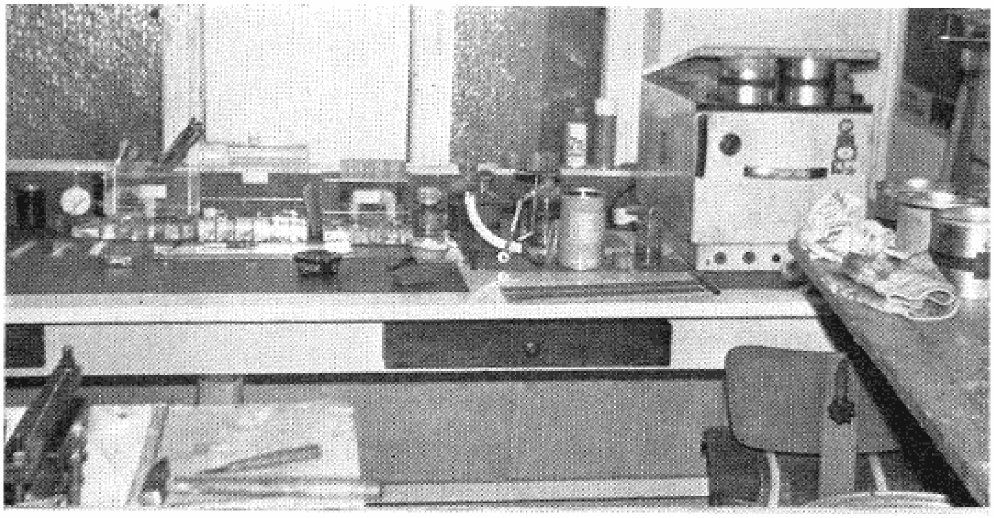
FIBRE GLASS PROPELLERS

Story of the Bartels production line

THIS story began in 1960 when Jurgen Bartels had done a few years of model flying. He was only interested in sports models and so was satisfied with the normal equipment one can buy in any hobby shop. After some time he tried to build a competition model, and his club grew in membership. Most of the local modellers built gliders and combat models. But in 1962 there was a championships for Northern Germany. The club leader told Jurgen to build a speed model, because some other clubs had built them too. Nobody knew anything about this type of model! So Jurgens tried to get information and bought an old Oliver Tiger from a friend. He had never flown such a fast model before and gained second place at 100 m.p.h. He did not know what had happened!

Some of the other modellers had Super-Tigres, which had been spoken of but not seen before. The first task after the competition was to buy such an engine. Jurgens built a new model for the Super Tigre but only managed a few miles per hour more. The main problem at this time was to get propellers for this new class. A few Tornado plasticoted props were obtained from the modellers already flying with S.T. engines, but a few months later they were off the market and were not apparently produced any more.

At this time Jurgens had a little experience with polyester, so he tried to make a mould to copy the Tornado prop before they were all broken. He made it out of gypsum but could only produce up to five before the mould became

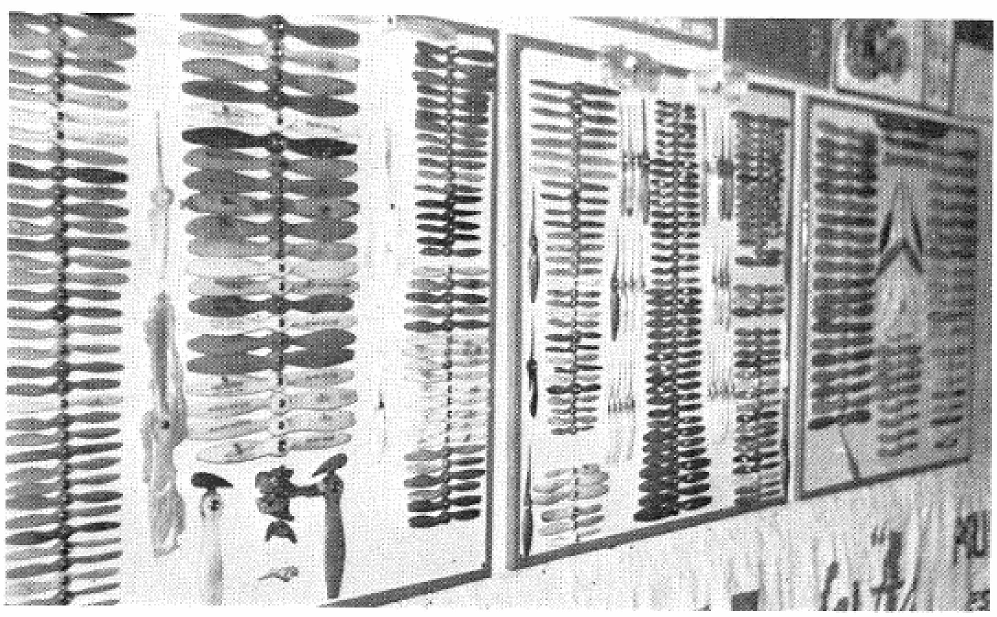


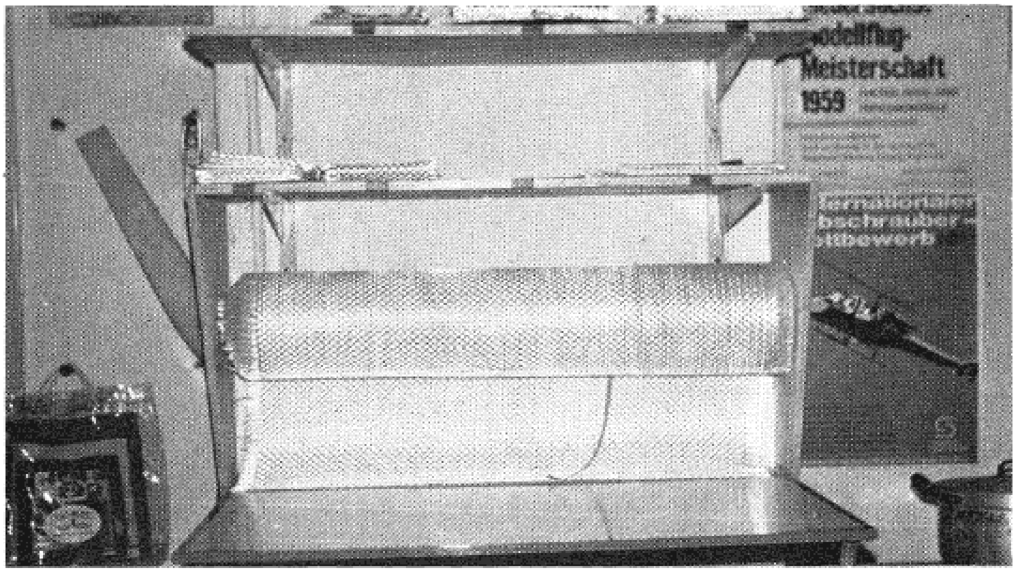
The work area, electric and epoxy pots, hardeners, balance.

damaged. Jurgen's mother provided ordinary wax for separation and the process was operated cold, of course.

At this time moulds were made one after the other, using glass fibre. This worked well but the props were very brittle. In 1963 Jurgens was introduced by friends working in a factory producing models for wind-tunnel tests to an epoxy formula. Work continued with epoxy and Jurgens made his first permanent mould, some of which are still in use today. A heat hardening epoxy was filled with steel dust. Jurgens heated the moulds up to 70°C in an electric oven, filled them and then let them get cold and harden. This took up to 3 or 4 hours per prop. The moulding was pressed between two pieces of steel with stout screws.

The enormous collection of propellers in the Bartels museum represents over 400 different designs from all parts of the world.



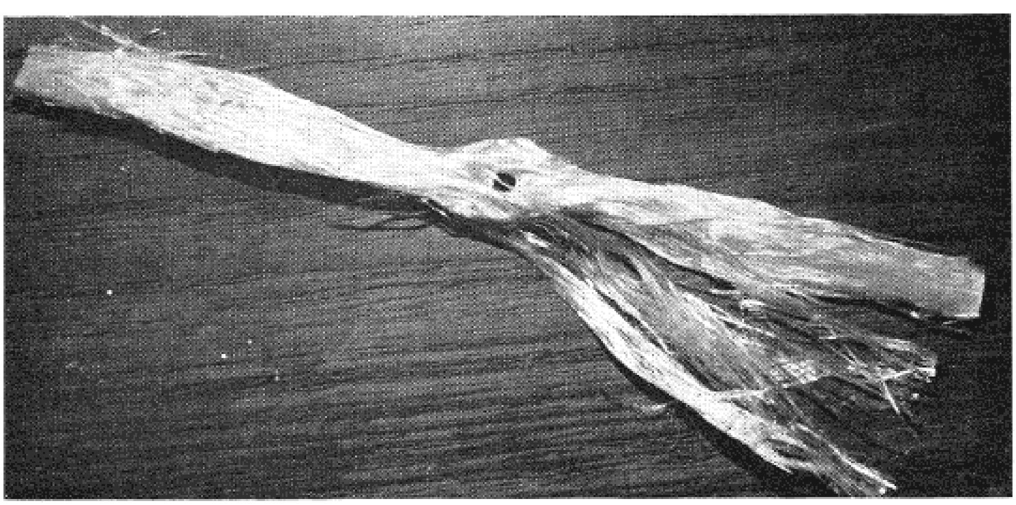


The roll of glass cloth from which all stock is drawn.

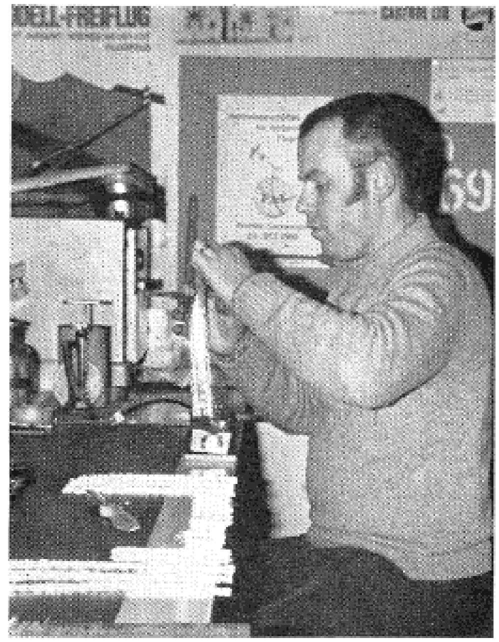
At first there were often bubbles in the props, but after squeezing them out with a special knife the problem was overcome. At this stage only speed props were produced for use. A factory in Southern Germany produced a T.R. prop for Karl Ilg (the German champion) known as the *Glasflugel* props. These suffered from splits from the tip to the middle when the engine was running slowly or the prop made contact with the ground. Karl Ilg talked to Jurgens about this and in 1965 the first T.R. props came out with cross-glass in the tips.

About 100 had been produced by the time of the 1966 Control Line World Championships at Swinderby. When the American team Stockton/Jehlik became world champions it was a great day for Jurgens. He was unaware that they used his props. Karl Ilg had given them to some of the contest fliers and about 30% were already using the 7 in. × 8 in. prop in team-racing.

A prop which has been subjected to a chemical burn, leaving the glass fibres intact, shows how much fibre is used in a propeller.



Starting the process, after cutting the glass strips and mixing epoxy.



Laying in the strips within the mould, a stage that calls for care.

Until 1968 the production line was run as a hobby. After Helsinki in 1968, when Stockton/Jehlik repeated their World Champs success, the business became too big for a part-time operation. More than 50% of the team racers at Helsinki were using the Bartels props, so Jurgens decided to go full time. In the meantime he had produced moulds for about fifteen types, and in the same year Werner Kaseberg flew his 320 km/h. world record in R/C speed. About 90% (10 of 11 participants) in the speed trials were using Bartels 10 in. × 12½ in. speed props. Free-flight power enthusiasts used glass fibre props extensively at Wiener-Neustadt in 1969.

A year later, at the Namur C/L World Champs, about 70% of the team race entrants were using the 7 in. × 8 in.

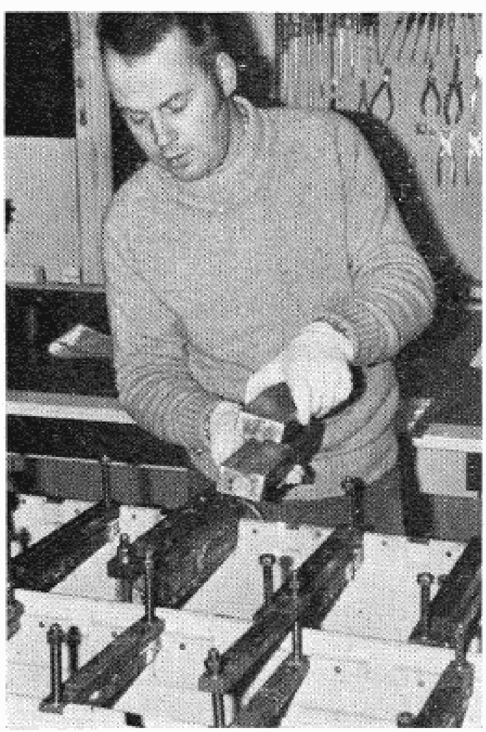
In 1971 Jurgens made the props for the U.S. team in F.A.I. Power for the World Champs. They had been using Cox 7 in. × 3½ in. plastic, but the high-revving Rossi's made the blades fly off after 6 or 7 seconds. Jurgens made the "specials" exclusively for the U.S. team to use at Gothenburg. Since that World Champs it has become used as a standard prop by most of the F/F competition fliers all over the world. The U.S. team tried many engines at Gotheborg with this prop for comparison.

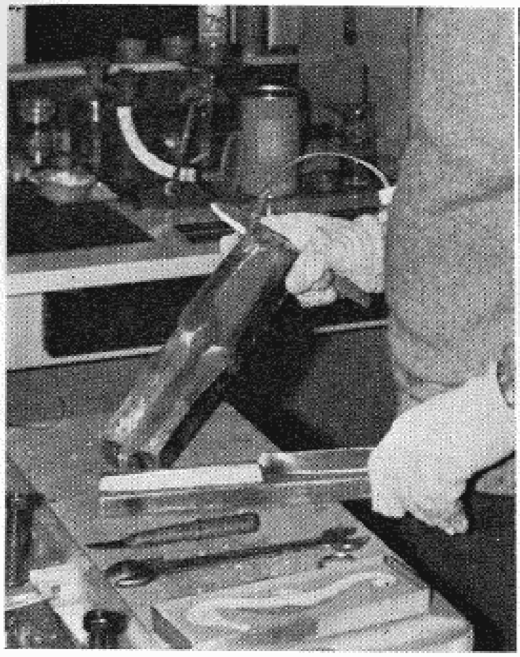
After the visit to the R/C World Champs at Doylestown in the U.S.A., Jurgens decided to expand his business and production. Up to the end of 1971 all the work had been done in his father's cellar. He found ideal rooms for his new shop. One big room (high up to disperse the epoxy fumes), one small room for a "museum" (props, old engines, souvenirs from World Champs), one room for machines (electric saw, lathes, drills and the mould-making material), and the whole cellar remaining for model building. Because of the full-time activity with the props, model flying had been neglected during the past years. Jurgens hopes to improve this situation in the future—but knowing a little of the hobby business, the Editors doubt if the demand will ever give him time to play.

Above: Bartel's biggest actually came from the W.W.I Richthofen Squadron!

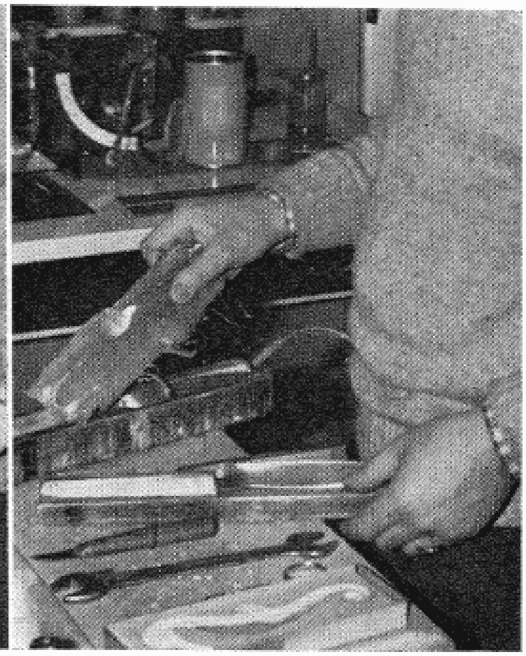
Above: Pressing out the bubbles with a special knife.

Below left: Fitting the upper mould half.
Below right: Pressing out the excess epoxy from the mould and heating to 100°C.





Opening the mould after 20 minutes.



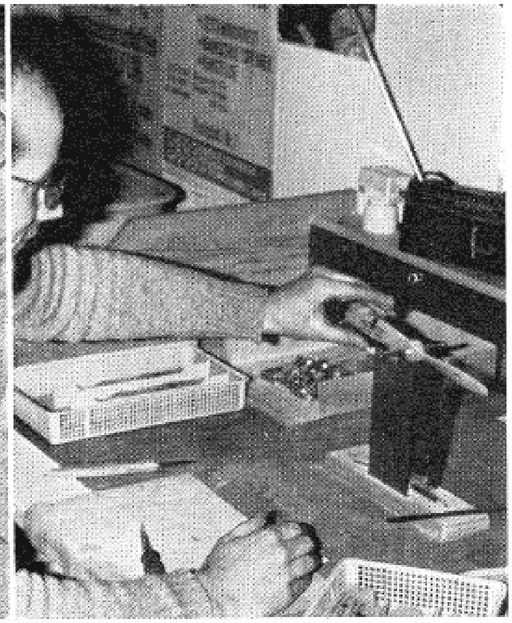
Removing the propeller from the mould

When making the master mould it is normally best to use a wooden prop, after checking the pitch and polishing it. Fix the prop on an aluminium plate with a polished pin in the centre. This is cast in place to produce the shaft hole in the prop afterwards. The undersurface of the prop is packed out with Plasticine. Thin metal sheets are fastened to build a "box" around the base plate. Into this, epoxy is poured, after both prop and plate are painted with silicone for separation. When this part is dry and hard, one has the upper part of the moulding. After this the thin metal sheets are put around this piece of epoxy to build a "box" again for casting the other half.

One only has to take out the Plasticine, to clean the master, and use silicone spray for separation again. Four pins are cast in place as location points, when the two parts are separated. After drying, the mould can be opened to remove the wooden master. The moulding is cleaned and polished with steel wool. Silicone is painted over the surfaces and the mould is ready for its first prop moulding in epoxy. Jurgens paints a little epoxy into the moulding first and then positions the first roving from "top to tip" around the middle pin. This is done until the moulding is filled. As the tips are thinner, the content has to be packed more in the middle. The upper part of the mould is laid in place and both parts are pressed between two steel plates, to expel the excess epoxy. This type of moulding is good for 100 props or more. If one needs more of one type (which is normal), cast copies are made of the first moulding in aluminium and electric heaters are fitted integrally. These are heated up to about 100°C and then one can get about 60–65% glass into the prop, which is ideal for the Bartels epoxy. The present collection of moulds covers twenty-four types of propeller.

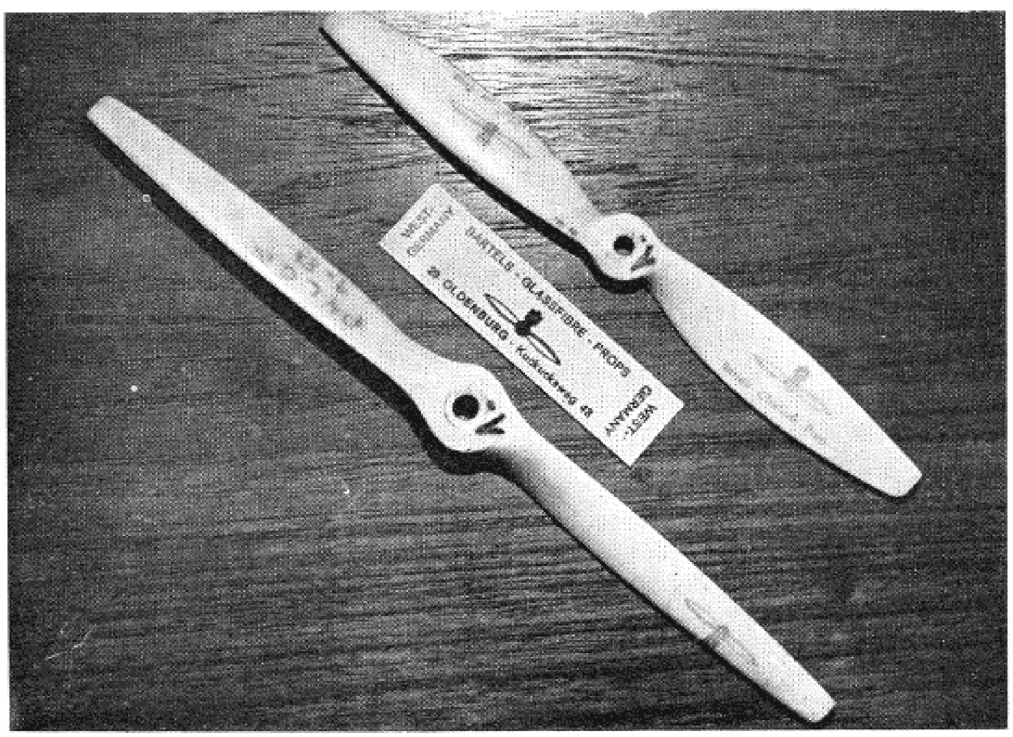
In 1972 experiments were made with carbon fibre, but the results were not as good as required. Carbon fibre can be very rigid, so the result is a very stiff prop. But as glass fibre splits at the tips, repairs can be made with epoxy after cleaning the tips with acetone. If one touches the ground with a running

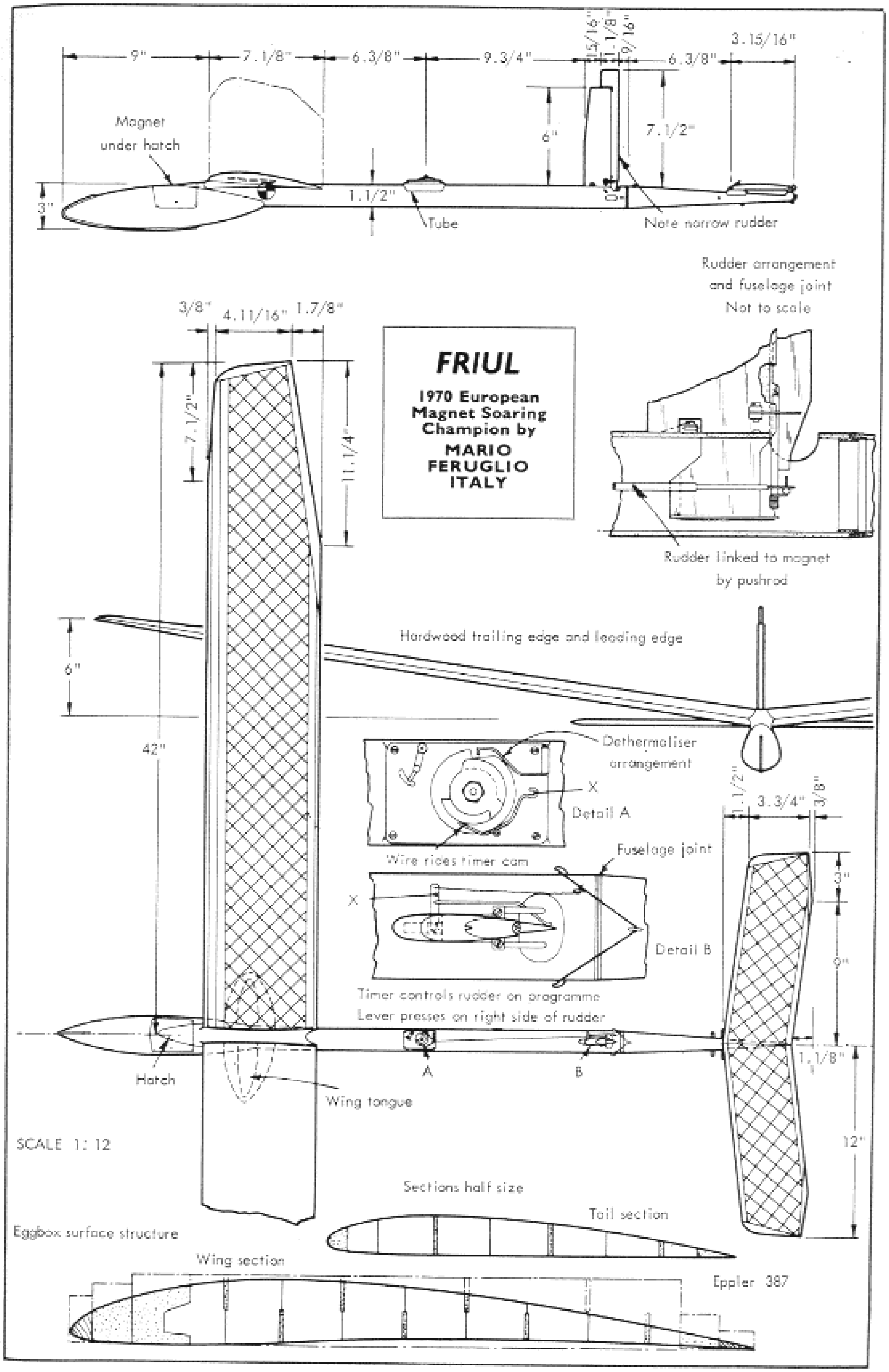
Cutting off the flash from the moulding.



Lutz Scholl, balancing a Bartels R/C prop.

engine, carbon fibre usually breaks. A mixture of 20% carbon, 45% glass and 35% epoxy was tried. These props are stuffer, especially for speed models. One can make the blades thinner. The cost of carbon fibre is another consideration. Although only a few grammes are needed you also require more time for working with this material. If CF becomes practical for production the props would cost twice the current epoxy price.





FLUG AND MODELL TECHNIK

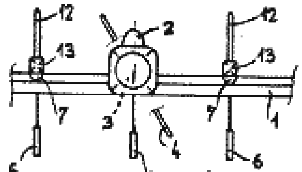


Fig. 2

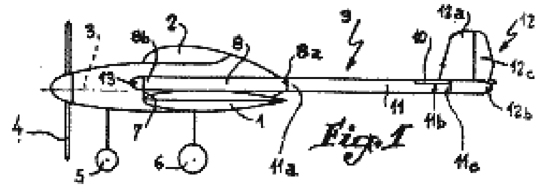


Fig. 1

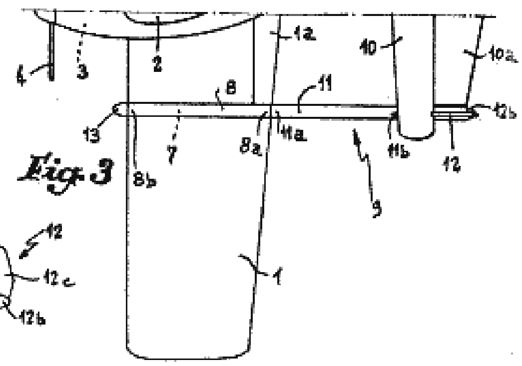


Fig. 3

Configuration classique

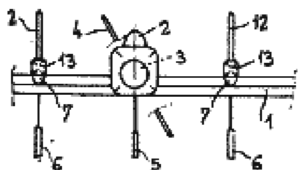


Fig. 5

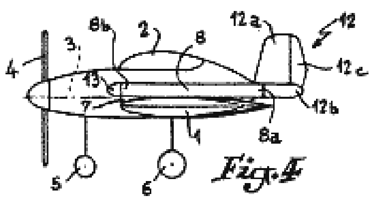


Fig. 4

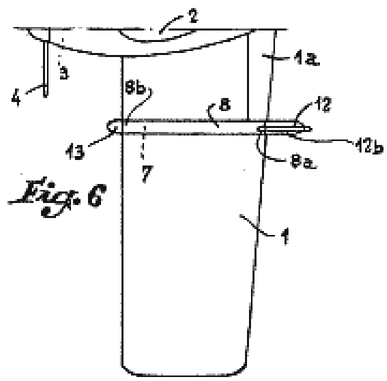


Fig. 6

Transformé en « Sans queue »

THE TRANSFORMABLE CONTROL-LINE MODEL

by PIERRE ROUSSELOT
Lyon, FRANCE

Patent illustrations show how components are interchangeable in three types of aircraft

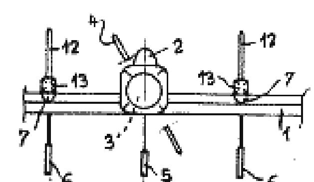


Fig. 8

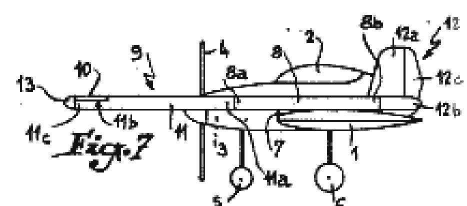


Fig. 7

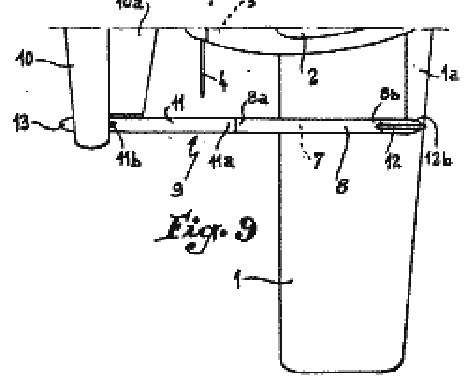
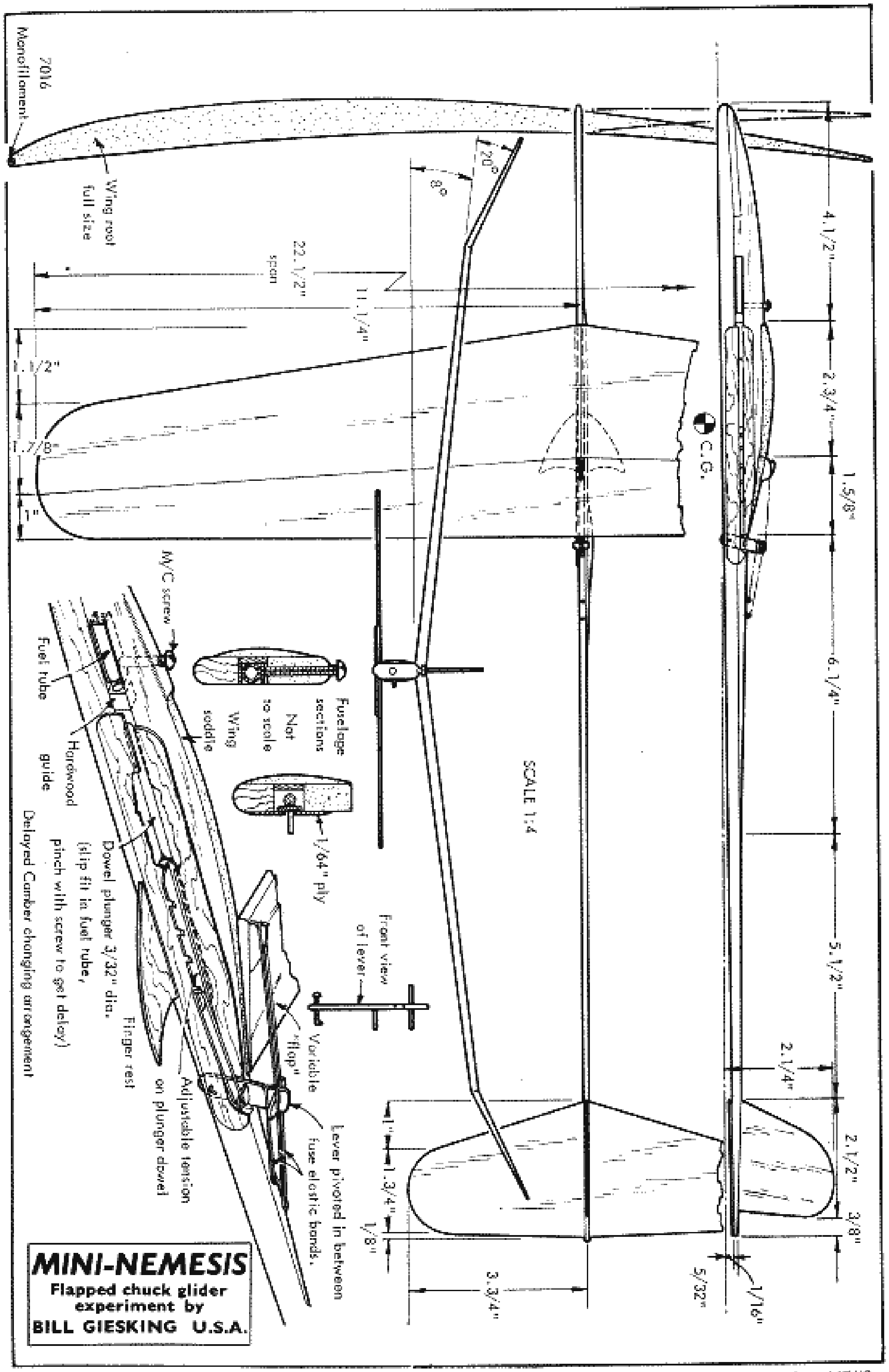


Fig. 9

Version « Canard »

Powered by a Webra .3.5 c.c. diesel, this "multi-version plane", as detailed in these Patent application sketches, can be operated as a twin-boom pusher, flying wing, twin-boom canard, or maybe other variations of its component parts. The prototype has performed in each of these transformations according to the French magazine *Le Modele Reduit d'Avion*. Asymmetric Blohm and Voss shapes are being considered and the transformable controliner is to be used as a contest model as it is fully aerobatic.


7016
Monofilament
Wing root
full size
20°
8°
22.1/2"
span
11.1/4"
1.1/2"
1.7/8"
1"
C.G.
4.1/2"
2.3/4"
1.5/8"
6.1/4"
5.1/2"
2.1/4"
2.1/2"
3/8"
1/16"
5/32"
3.3/4"
1/8"
1.3/4"
1"
SCALE 1:4
Fuselage
sections
Not
to scale
Wing
saddle
1/64" ply
Front view
of lever
M/C screw
Fuel tube
Hardwood
guide
Dowel plunger 3/32" dia.
(slip fit in fuel tube,
pinch with screw to get delay)
Delayed Camber changing arrangement
Finger rest
Variable
"flap"
Adjustable tension
on plunger dowel
Lever pivoted in between
fuse elastic bands.
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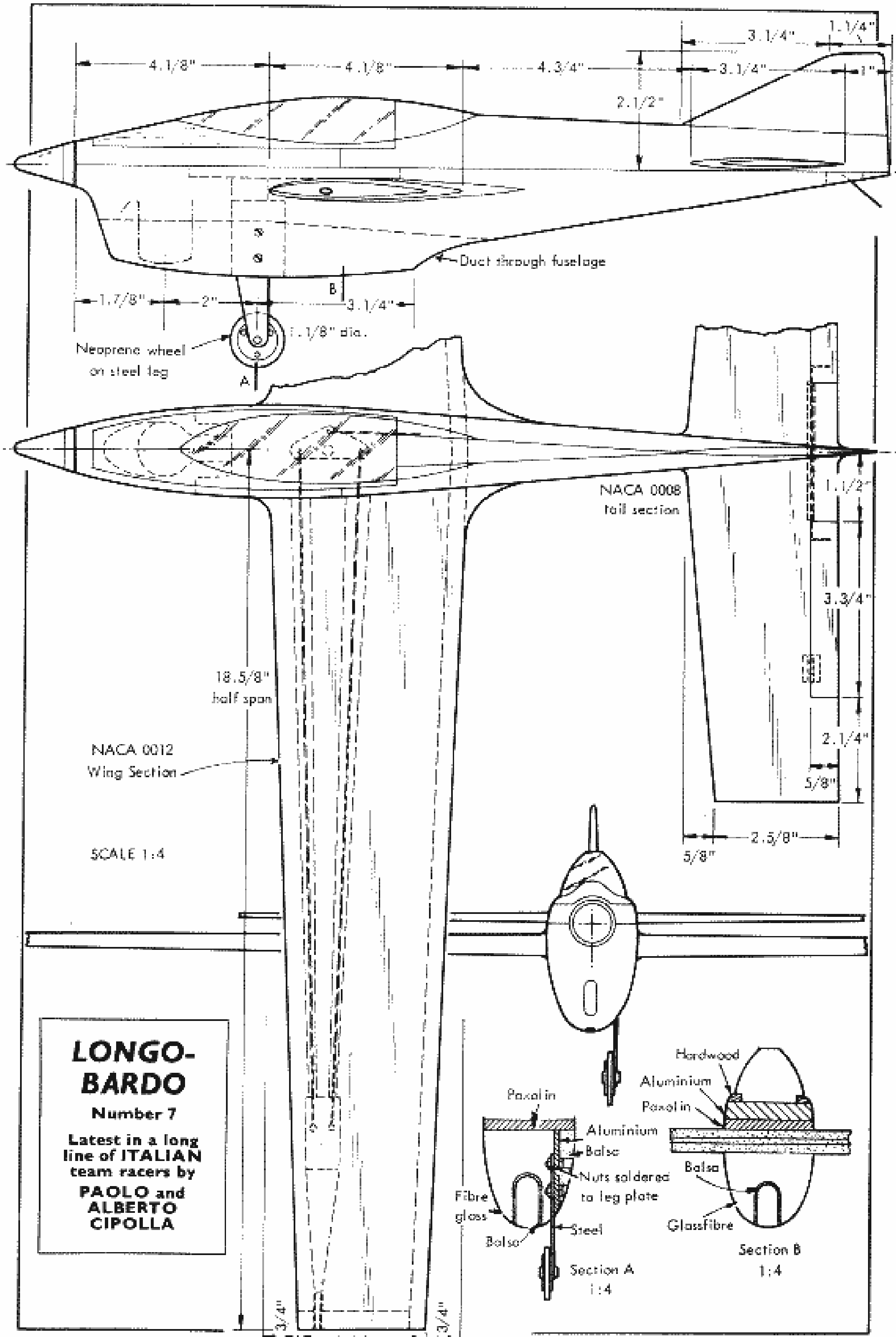

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Number 7

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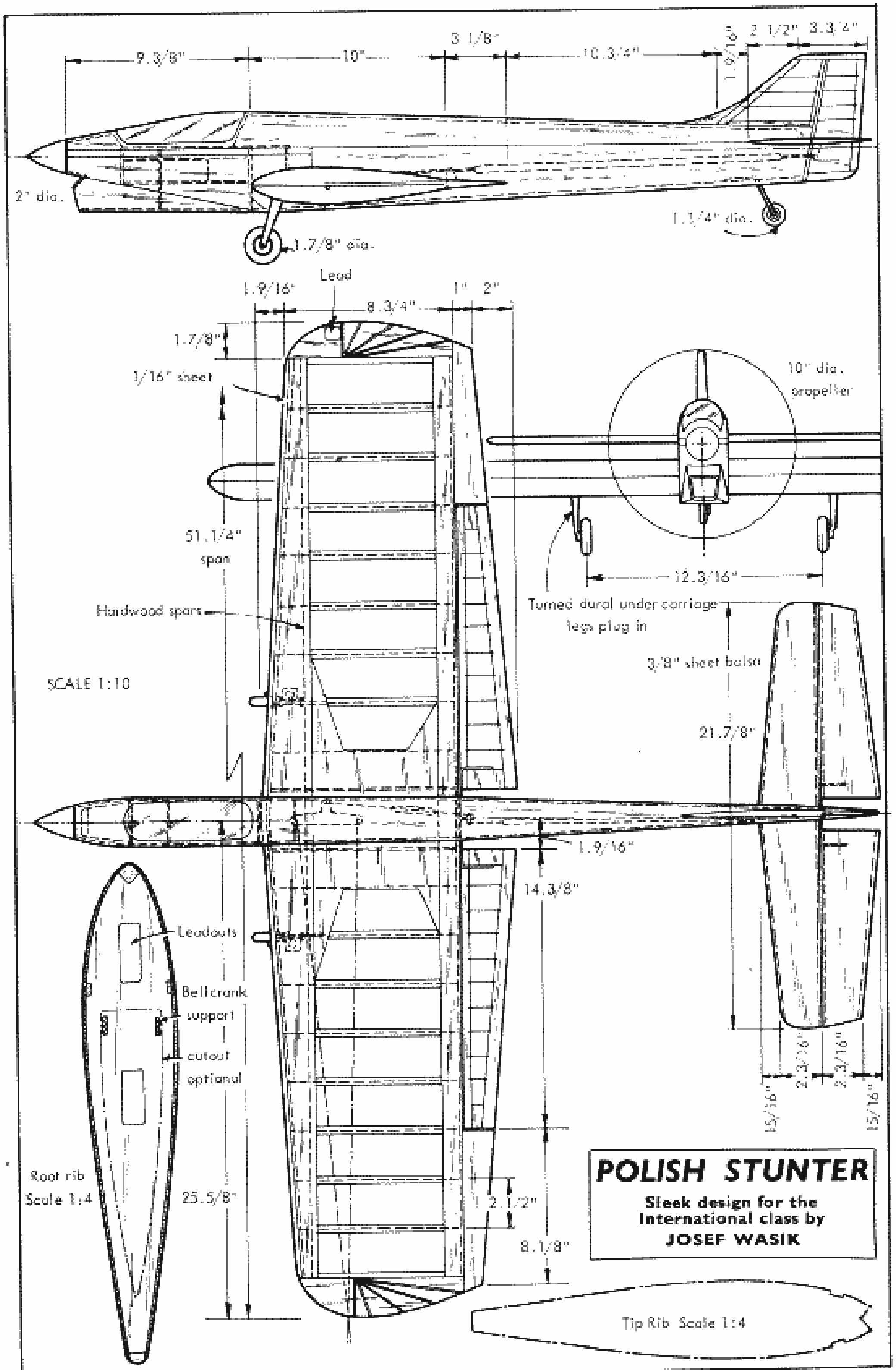

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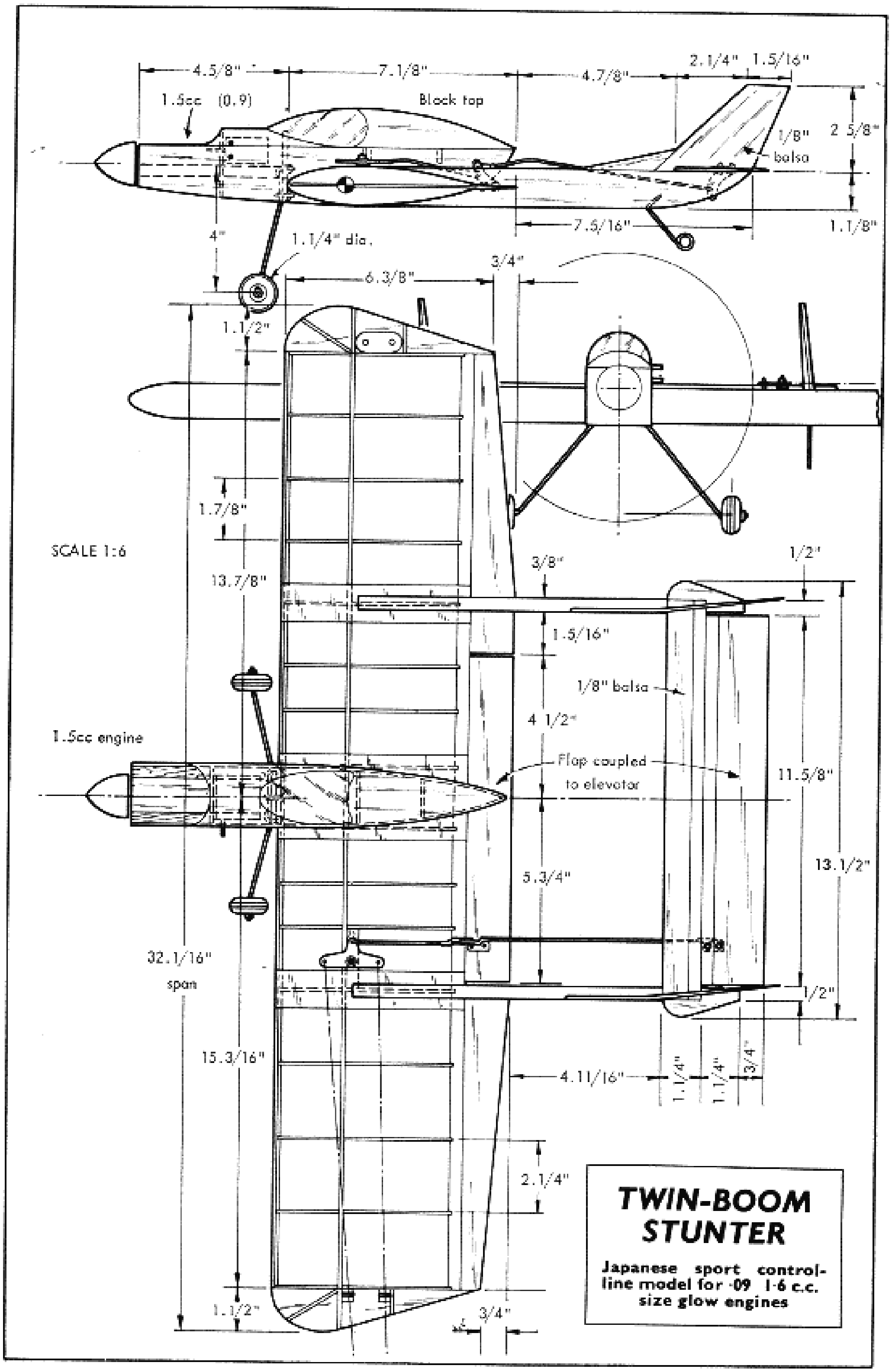


C/L TECHNIQUE

F.A.I. WORLD RECORDS (as at 1-7-72)

Free Flight
Class F-1-B
RUBBER DRIVEN

No. 1 **Duration**
V. Fiodorov (*U.S.S.R.*), June 19th, 1964 ... ... 1h. 41m. 32s.

No. 2 **Distance in a straight line**
G. Tchiglitsev (*U.S.S.R.*), July 1st, 1962 ... ... 371·189 km.

No. 3 **Altitude**
V. Fiodorov (*U.S.S.R.*), June 19th, 1964 ... ... 1,732 m.

No. 4 **Speed in a straight line**
P. Motekaytis (*U.S.S.R.*), June 20th, 1971 ... ... 144·9 km/h.

POWER MODELS
Class F-1-C

No. 5 **Duration**
I. Koulakovsky (*U.S.S.R.*), August 6th, 1952 ... ... 6h. 1m.

No. 6 **Distance in a straight line**
E. Boricevitch (*U.S.S.R.*), August 15th, 1952 ... ... 378·756 km.

No. 7 **Altitude**
G. Lioubouchkine (*U.S.S.R.*), August 13th, 1947 ... ... 4,152 m.

No. 8 **Speed in a straight line**
Doubenitsky and Laryukhin (*U.S.S.R.*), September 25th, 1971 ... ... 169 km/h.

RUBBER-DRIVEN HELICOPTER
Class F-1-F

No. 9 **Duration**
A. Nazarov (*U.S.S.R.*), June 3rd, 1968 ... ... 33m. 26·7s.

No. 10 **Distance in a straight line**
V. Kramarenko (*U.S.S.R.*), June 3rd, 1968 ... ... 4,653·5 m.

No. 11 **Altitude**
A. Voltchanovsky (*U.S.S.R.*), June 4th, 1968 ... ... 352 m.

No. 12 **Speed in a straight line**
P. Motekaitis (*U.S.S.R.*), June 12th, 1970 ... ... 144·23 km/h.

POWER-DRIVEN HELICOPTER
Class F-1-A

No. 13 **Duration**
S. Purice (*Rumania*), October 1st, 1965 ... ... 3h. 12m.

No. 14 **Distance in a straight line**
V. I. Titlov (*Hungary*), October 1st, 1963 ... ... 91·491 km.

No. 15 **Altitude**
S. Purice (*Rumania*), September 24th, 1963 ... ... 3,750 m.

No. 16 **Speed in a straight line**
A. Pavlov (*U.S.S.R.*), September 20th, 1970 ... ... 116·12 km/h.

GLIDERS
Class F-1-A

No. 17 **Duration**
M. Milutinovic (*Yugoslavia*), May 15th, 1960 ... 4h. 58m. 10s.

No. 18 **Distance in a straight line**
Z. Taus (*Czech*), March 31st, 1962 ... ... 310·33 km.

No. 19 **Altitude**
G. Benedek (*Hungary*), May 23rd, 1948 ... ... 2,364 m.

INDOOR MODELS
Class F-1-D

No. 32 **Duration**
K. H. Rieke (*W. Germany*), September 22nd, 1962 ... 45m. 40s.

No. 32a* **Less than 8 m. ceiling**
Duration
J. Kalina (*Czech*), September 13th, 1969 ... ... 21m. 6s.

No. 32b **8–15 m. ceiling**
Duration
Jiri Kalina (*Czech*), August 26th, 1970 ... ... 30m. 7s.

RADIO CONTROL POWER DRIVEN
Class F-3-A

No. 20 **Duration**
Maynard Hill (*U.S.A.*), June 1st, 1969 ... ... 11h. 32m. 30s.

No. 21 **Distance in a straight line**
A. Bellochio (*Italy*), July 25th, 1969 ... ... 377·350 km.

No. 22 **Altitude**
M. Hill (*U.S.A.*), September 6th, 1970 ... ... 8,208 m.

No. 23 **Speed in a straight line**
Goukoune and Myakinine (*U.S.S.R.*), September 21st, 1971 ... ... 343·92 km/h.

No. 31 **Distance in a closed circuit**
B. Kunce (*U.S.A.*), February 17th, 1968 ... ... 338·04 km.

R/C SEAPLANE

No. 48* **Duration**
W. Kaiser (*W. Germany*), April 4th, 1972 ... ... 6h. 18m. 17s.

No. 49 **Distance in a straight line**
R. D. Reed (*U.S.A.*) February 26th, 1972 ... ... 133·875km.

No. 50 **Altitude**
M. Hill (*U.S.A.*), September 3rd, 1967 ... ... 5,651 m.

No. 51 **Speed in a straight line**
Goukoune and Myakinine (*U.S.S.R.*), October 25th, 1971 294 km/h.

No. 52 **Distance in a closed circuit**
W. Kaiser (*W. Germany*) May 1st 1972 ... ... 238·85 km.

R/C GLIDERS
Class F-3-B

No. 24* **Duration**
W. Kaiser (*W. Germany*), July 3rd, 1969 ... ... 17h. 43m.

No. 25 **Distance in a straight line**
G. Martin (*U.S.A.*), April 12th, 1970 ... ... 34·6 km.

No. 26 **Altitude**
Raymond Smith (*U.S.A.*), September 2nd, 1968 ... ... 1,521 m.

No. 33 **Speed in a straight line**
L. Aldoshin (*U.S.S.R.*), October 9th, 1971 ... ... 182 km/h.

No. 34 **Distance in a closed circuit**
R. Brogly (*France*), September 7th, 1970 ... ... 322·2 km.

R/C HELICOPTER
Class F-3-C

No. 35 **Duration**
M. Kufner (*W. Germany*), January 29th, 1972 ... 1h. 12m. 23·5s.

No. 37 **Altitude**
E. F. Rock (*U.S.A.*), September 6th, 1971 ... ... 198 m.

No. 39 **Distance in a closed circuit**
D. Schluter (*W. Germany*), June 20th, 1971 ... ... 11·5 km.

CONTROL LINE
Class F-2-A

No. 27 **Speed (2·5 c.c.)**
Lauderdale/McDonald (*U.S.A.*), May 4th, 1963 ... 273·66 km/h.

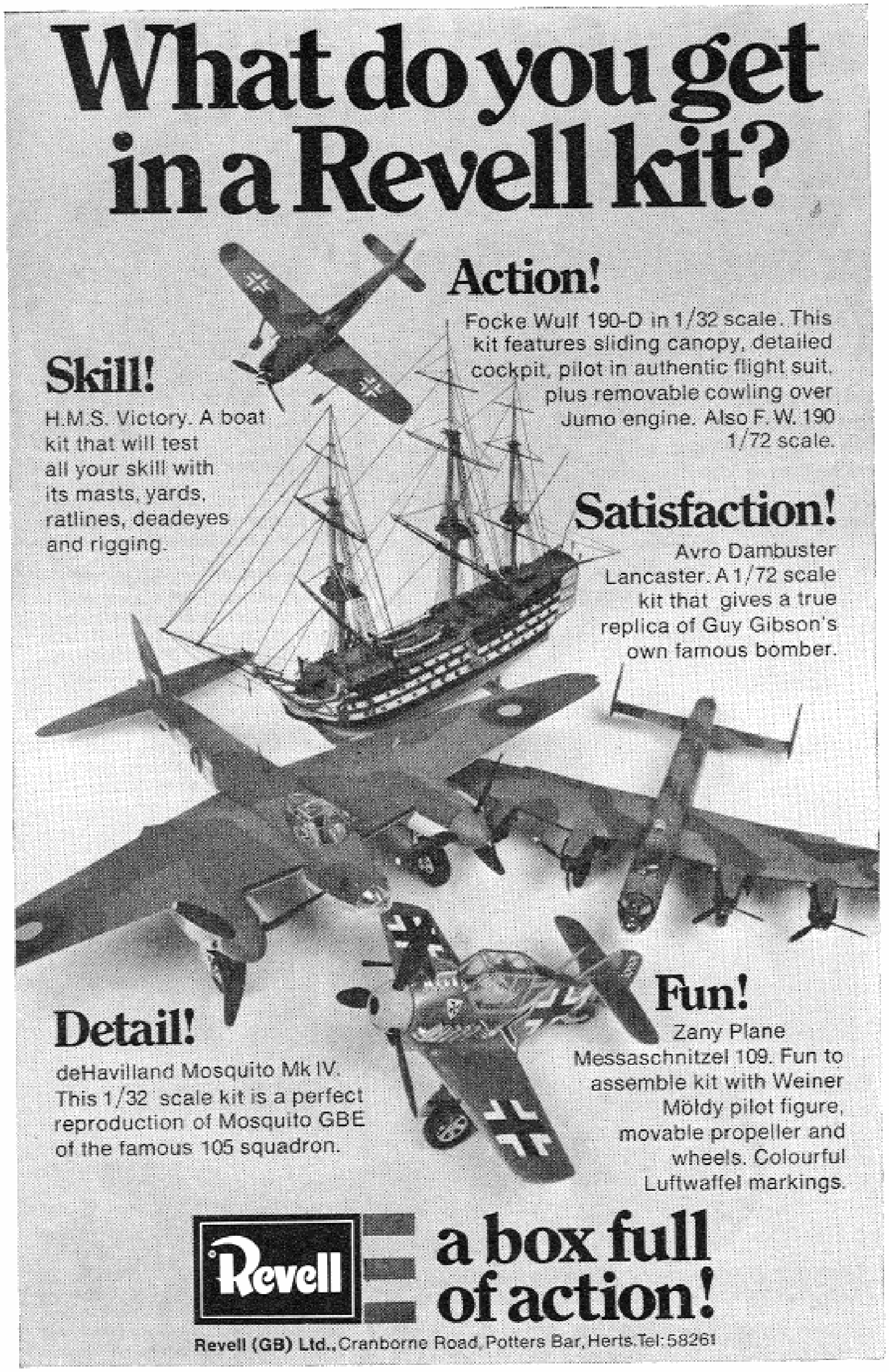
No. 28 **Speed (2·5–5 c.c.)**
McDonald (*U.S.A.*), November 15th, 1964 ... ... 288·95 km/h.

No. 29 **Speed (5–10 c.c.)**
V. Kouznetsov (*U.S.S.R.*), September 30th, 1962 ... 316 km/h.

JET MODELS

No. 30 **Speed**
L. Lipinsky (*U.S.S.R.*) ... 395·64 km/h.
December 6th 1971

* Improved claims pending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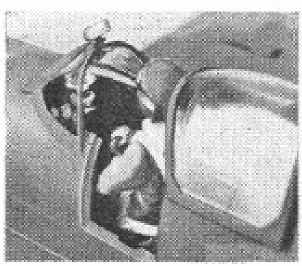

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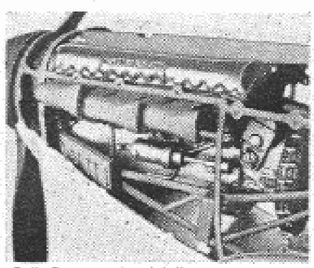
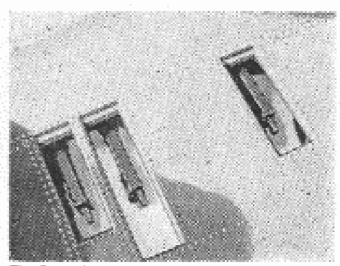


Rolls-Royce engine detail



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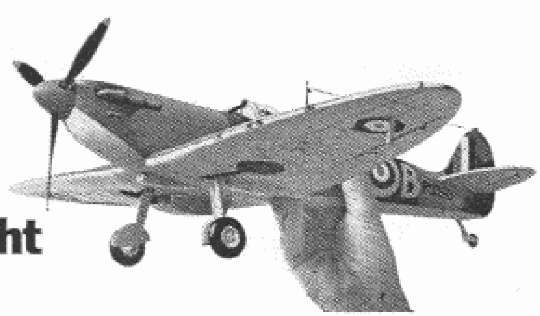

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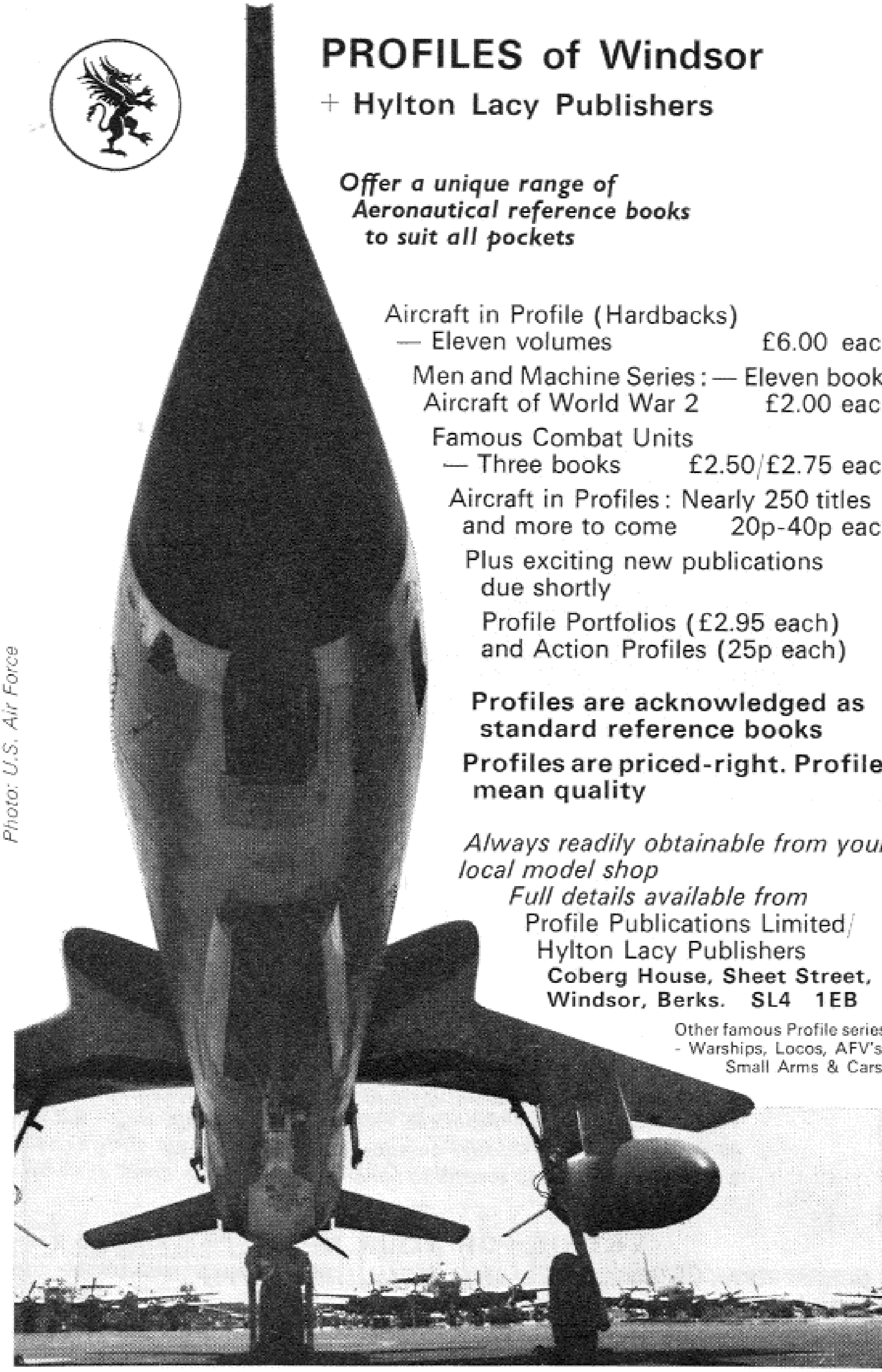

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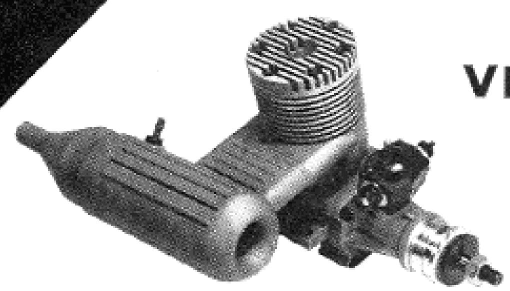

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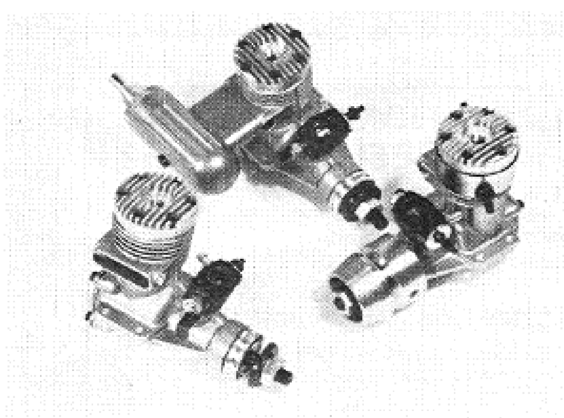

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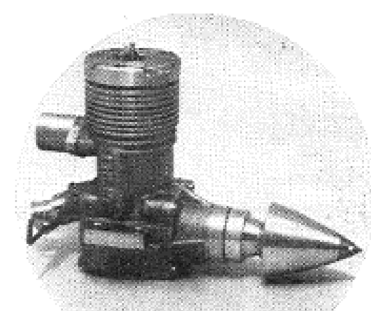

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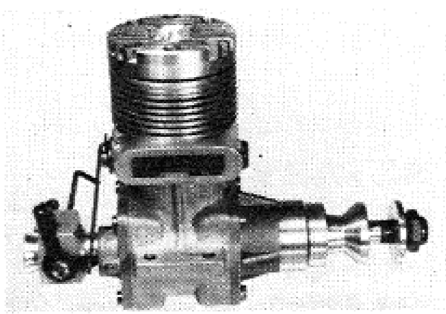

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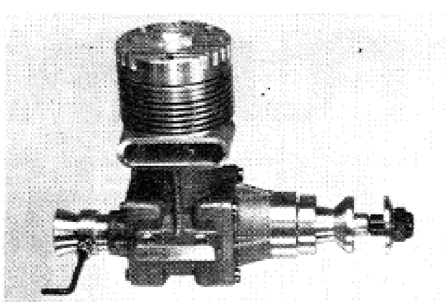

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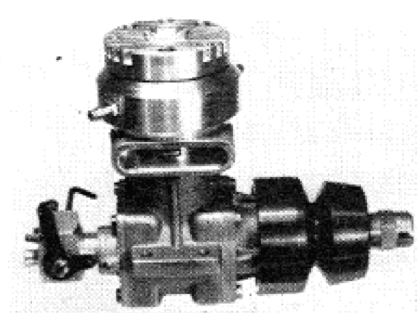

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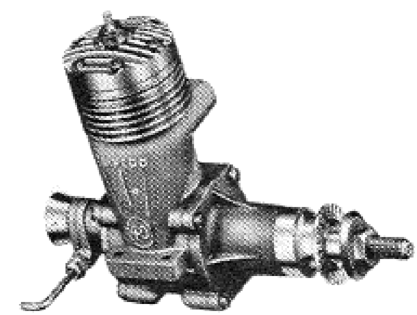

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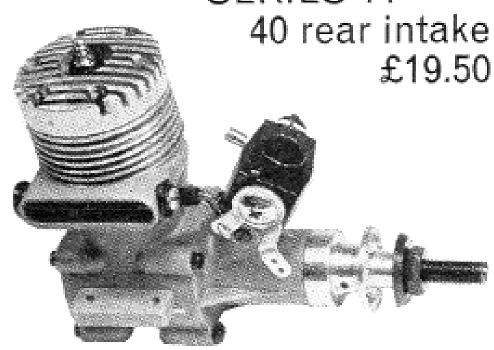

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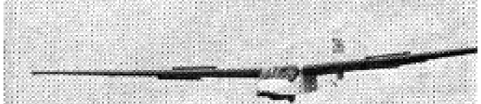

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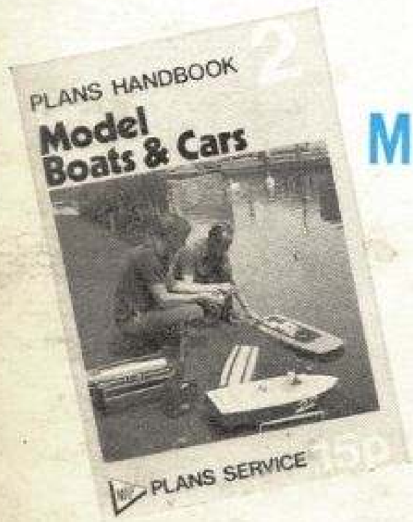

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