1951-52 MODEL AERONAUTIC YEAR BOOK by Frank Zaic

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MODEL AERONAUTIC
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Edited by

Frank Zaic

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To the memory
of my father

FOREWORD

When you look at a model airplane, resting on the ground, it looks so simple; just a wing, tail, fuselage and a prop. Yet, this collection of odds and ends can bring joy or sadness to our hearts by the way it takes to the air.

When you look at a model and note its simplicity, and then look at the seemingly complex literature in this book you have a real cause to question: It is really so?

When you look at a bird as it flies through the air with a natural ease, it looks so easy to do. Yet, when we think of it, who else besides God can make a bird?

When you look at a model, resting on the ground, always remember that it is a different object in the air. On the ground, it just rests. But in the air, it has to possess uncanny ability to counteract all the forces that have held men earthbound since time began. Would you say that it is a simple thing to do?

When you look through this book, keep the above ideas in mind, and you will find that the complex will become gradually less complex, and your heart will be more often joyful than sad when you fly your pride and joy.

To help you find that which you are seeking, is the purpose of this book.

FRANK ZAIC.

March, 1952
Ithaca, N. Y.

1951-1952 YEARBOOK

It is over 12 years since we wrote the 1938 Edition of the Year Book. We wonder how many of our original readers will read this edition. Well, be as it may, let us see what happened in the field of Model Aerodynamics since then.

To us, writing the Year Books has always been a period in which we try to find answers to our own questions. So that, in a sense, we do this work to satisfy our own curiosity. If you find statements with which you do not agree, we will be very glad to hear your views.

TOO MANY PAGES

When we began this book we had no idea just how much space we would need for the technical text. As we began to clear up one question after another, new problems came up which required more space. To save time, we had the material set-up in type. As we approached the end of the text, we found ourselves with more material than could be squeezed into this book, and we still had to consider plans and outside contributions.

Since we tried to find reasons for the behavior of the very basic forces, we covered the subject in great detail. It would, therefore, be wasteful to discard the work done, and just give you the summary of what we did. Under such circumstances, the logical solution is to print the highlights in this book, and then publish the complete text in another book. Thus, if you find that some of the actions do not seem clear in this book, you will find their complete background in the other book.

OUR FIRST PROBLEM

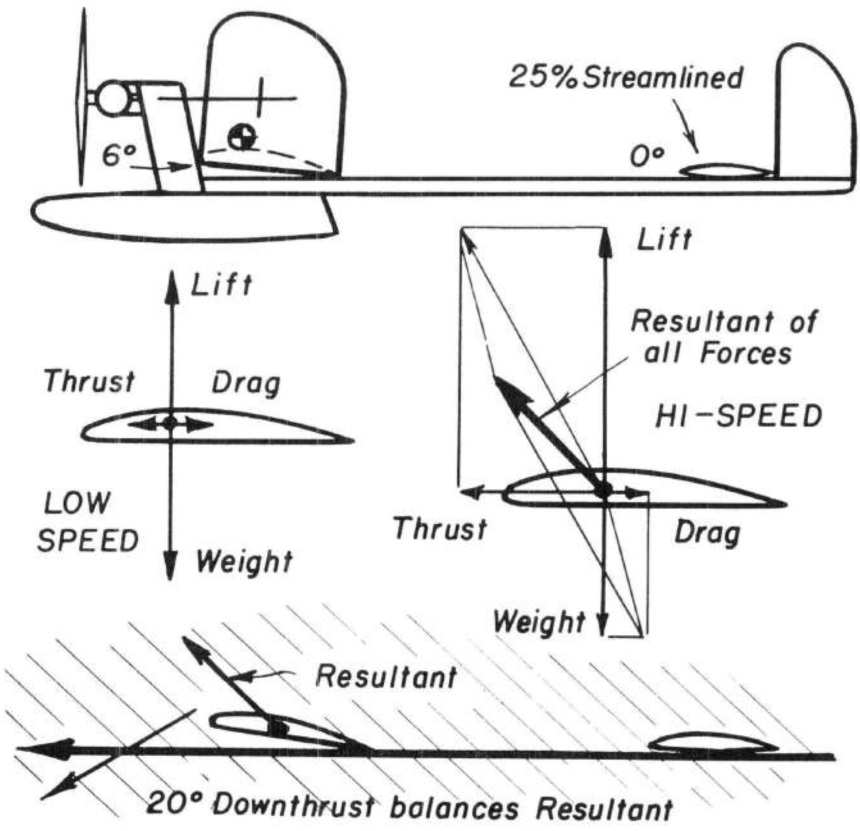
Our basic problem is to determine the exact position of the model while it is flying. We know that it is out there somewhere, and we can see it. But we want to know just what is it's position in relation to the airflow. If we knew that, we could find out why it behaves as it does at times.

Our first lead was the fact, that, when we adjust models to glide as slow as possible, we automatically bring the wing close to its stalling angle. From tests and logical thinking, we found that the stalling angle occurs around 6° angle of attack.

THE CLASSICAL EXPERIMENT

Working under the impression that the 6° angle of attack exists under all flight conditions, we made a test model as shown. Our idea was to have the wing held to 6° under all flight conditions. To make sure that the drag would have no moment arm about the thrust line, or that the thrust line would have no looping force about the C.G., we placed the motor high so that its thrust was an inch above C.G. And also through the wing's center of lift and drag.

All this led us to believe that we would have a fast and a 45° climb. And we were even worrying about having it dive. Comes the revelation.



THE REVELATION

Our first glide test was perfect. Our first power test was a perfect loop. If we had nct stepped out of the way fast enough, you would be reading wild stuff now. We spent ten days trying to stop it from looping. (Complete details in the other book.) Let's arouse your curiosity by saying that, at one time, we had the C.G. ½ inch in front of the leading edge while the model was climbing at 45°. Glide? Vertical. We eventually brought looping under control by using 20° downthrust in relation to the wing.

As you will read on, you will know why we picked Model Aerodynamics apart as we have in this book. After the humiliation we had to crawl through, it was do or retire. Well, be as it may, we found the following facts from the test.

Towards the end of the test, we began to realize that under high power, the model develops more lift than under glide. If this is the case, what happens to the forces generated? In a level flight, the condition would be as shown: Thrust just strong enough to overcome drag at the speed at which the wing generated enough lift to take care of the weight. But the power we use now is almost equal to the weight of the model. If model weighs 8 ozs. it usually is powered with an .09. An .09 could have 8 ozs. thrust. This power will increase speed. Say it was enough to double the lift. Now, see what happens to our force. After resolving, we have a resultant which is angled 45° with nothing holding it back from going in the direction of 45°. To us this means that the model wants to move in this direction. If the model was in a horizontal position, the movement towards 45° would mean a reduction in the "over all" angle of attack. Later on you will see that if you reduce the over all angle of attack on a model, that is trimmed for 6°, the wing will have greater power about the C.G. This will tend to loop the model.

The above is just our explanation. It is quite possible that there is another one. All we know is that when power is applied, a model, that was balanced for a glide, will have a looping or zooming tendencies. The degree of looping or zooming will depend on the design.

Also, this zooming action of the model, under high power, automatically adjusts the model to the new conditions. You will find out how.

PITCHING MOMENT CHARTS AND GRAPHS

Starting with this 6° angle, we knew that the model had to be balanced somehow, so that it retained these adjustments during the glide. Our problem was to find out which factors play a part in this particular balance. Then, a letter from Hewitt Phillips, in response to our call for help, got us started on PITCHING MOMENTS.

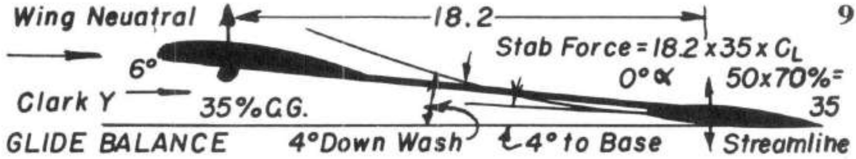
After we began to explore this phase of designing, we found that we could explain many actions which automatically happen on models; actions that have been going on for years but without anyone in the model field knowing about them.

The Pitching Moment Chart is nothing else but a listing of forces as they happen to be in a particular angle of attack. By knowing the value of these forces in a particular angle of attack, a designer can tell what must be done to correct trouble, or bring about new conditions. The method for finding the value of the forces is simple, providing you have the required information on hand. Our job was a bit harder, as we had to make up rules as we went along. Also, we had to assume many things which may not actually be so. However, the fact remains that we now have a method, good or bad, by which we can make some prediction of model's flying possibilities, before the model is made.

Our basic assumption was that the model should be balanced while the wing had 6° angle of attack. All other factors had to be made to fit the situation by a series of trial and errors. Our major problem was the Downwash Angle. We have no definite values for models. So, we juggled full size formulas, and found one that helped us produce the desired balance. This formula may not be exactly what is needed, but it did give us results which seem to fit our flying experience. By using this Downwash Formula, we were able to use stabilizer areas now in practice, and also have the stabilizer in similar angular relationship as we have on the actual flying models. So you can see the fun we had; trying to fit full scale data to model work, and make modifications as we went along, to make it agree with actual model practice.

MAKING PITCHING MOMENT CHARTS

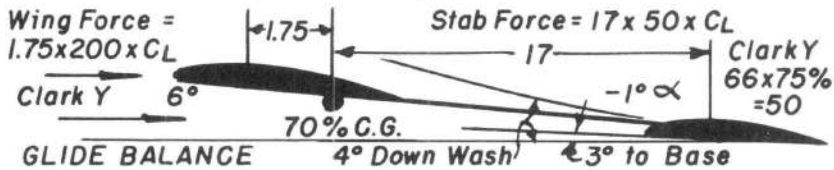
The charts we made are shown. Note the items used. Since our job was to find the balance when the wing was at 6°, we had to make the stabilizer to fit the situation. At first we had trouble finding a stabilizer that would fit the situation, and still be something we would recognize in actual practice. The key to the answer was the Downwash Formula. We reduced a text book formula to this: Wing C_L x 5 = Downwash Angle. This is in round numbers, and it is good when stabilizer is between two and four chords from the wing, and not higher, nor lower, than half Chord. Knowing the physical setting of the stabilizer in relation to the wing, we just subtract the downwash angles from such setting, to find the true angle of attack for the stabilizer. For example: On the 70% C.G. model, when the wing's angle of attack is 3°, the downwash is also 3°. The incidence of the stabilizer at this point is 0°. Subtract 3° downwash from zero and we have –3°. When the wing is at 0°, the downwash is 2°. The stabilizer incidence is –3°. Downwash means that the true angle of attack on the stabilizer will be less than the incidence setting. So, 2° less than –3° is –5°. Play around for a while and you will get the idea.



W.A.	W.C_L	D.W.	S.A.	AS.A.	S.C_L x S.M. = S.F.	
-2°	.25	1.2°	-4°	-5.2°	-.52 x 638 = -330	In Glide
-1°	.33	1.6°	-3°	-4.6°	-.46 x 638 = -300	Stab
0°	.4	2°	-2°	-4°	-.4 x 638 = -250	brings
1°	.47	2.3°	-1°	-3.3°	-.33 x 638 = -200	wing
2°	.54	2.7°	0	-2.7°	-.27 x 638 = -170	into
3°	.62	3.1°	1°	-2.1°	-.21 x 638 = -135	higher
4°	.7	3.5°	2°	-1.5°	-.15 x 638 = -96	angle
5°	.76	3.8°	3°	-.8	-.08 x 638 = -51	
6°	.82	4.1°	4°	0	0 x 638 = 0	Balance
7°	.88	4.4°	5°	.6°	.06 x 638 = 37	Stab
8°	.95	4.8°	6°	1.2°	.12 x 638 = 70	to O

W.A.= Wing angle of Att.
W.C_L= Wing Lift. Coef.
D.W = Wing Down Wash
S.A.= Stab Incidence

W.M.= Wing Area x Moment Arm W.F.= Wing Force S.F.= Stab Force
A.S.A.= Actual Stab angle of Att. S.C_L= Stab Coef. S.M. = St. Area x M.A.

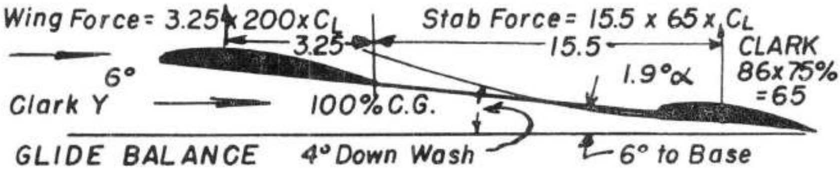


W.A.	C_L x W.M = W.F.	D.W.	S.A.	A.S.A.	S.C_L x S.M. = S.F	
-2°	.25 X 350 = 88	1.2°	-5°	-6.2°	-.05 x 850 = -42	In Glide
-1°	.33 x 350 = 116	1.6°	-4°	-5.6°	0 x 850 = 0	Wing
0	.4 x 350 = 140	2°	-3°	-5°	.05 x 850 = 42	lifts
1°	.47 x 350 = 162	2.3°	-2°	-4.3°	.1 x 850 = 85	up to
2°	.54 x 350 = 189	2.7°	-1°	-3.7°	.15 x 850 = 127	higher
3°	.62 x 350 = 217	3.1°	0	-3.1°	.19 x 850 = 161	angles
4°	.7 x 350 = 245	3.5°	1°	-2.5°	.22 x 850 = 187	
5°	.76 x 350 = 266	3.8°	2°	-1.8°	.26 x 850 = 221	
6°	.82 x 350 = 287	4.1°	3°	-1°	.33 x 850 = 280	Balance
7°	.88 x 350 = 300	4.4°	4°	-.4°	.37 x 850 = 314	Stab
8°	.95 x 350 = 332	4.8°	5°	.2°	.42 x 850 = 357	up

ANALYZING THE CHARTS

It is surprising how much you can learn by looking at these charts. Take the 35% C.G. for an example. Note that a force of 51 units is needed to counteract the stabilizer action if we wish to bring the wing to 5°. And if you want to bring the wing to 0°, you will need 250 units. In some of our calculations, shown in the other book, we found that to bring this model down to 0° angle of attack, an 8 oz. thrust engine would have to be mounted 4 inches above the C.G. to obtain the needed "downthrust," and to offset the forces of the stabilizer.

On the 70% C.G. model, downthrust force of **45** units is needed to bring the wing to 5°. And to bring it to 0°, the downthrust needs 100 units.



W.A	C_L x W.M. = W.F.	D.W.	S.A.	A.S.A.	S.C_L x S.M.= S.F.	In
-2°	.25 x 650 = 160	1.3°	-2°	-3.3°	.135 x 1000 = 135	Glide
-1°	.33 x 650 = 220	1.6°	-1°	-2.6°	.20 x 1000 = 200	Wing
0	.4 x 650 = 260	2°	0	-2°	.245 x 1000 = 245	Lift
1°	.47 x 650 = 310	2.3°	1°	-1.3°	.295 x 1000 = 295	up
2°	.54 x 650 = 350	2.7°	2°	-.7°	.34 x 1000 = 340	to
3°	.62 x 650 = 403	3.1°	3°	0°	.393 x 1000 = 393	high
4°	.7 x 650 = 455	3.5°	4°	.5°	.45 x 1000 = 450	Angle
5°	.76 x 650 = 494	3.8°	5°	1.2°	.49 x 1000 = 490	
6°	.82 x 650 = 533	4.1°	6°	1.9°	.533 x 1000 = 533	Balan
7°	.88 x 650 = 572	4.4°	7°	2.6°	.58 x 1000 = 580	Stab
8°	.95 x 650 = 622	4.8°	8°	3.2°	.64 x 1000 = 640	Up

The 100% C.G. design should be of special interest to most of us who fly gas models. It is a set-up used by almost all. To bring the wing to 5°, only 4 units of downthrust are needed. And to bring it to 0°, 15 units will do it. Quite a contrast to the other two. (8 oz. thrust, ¼ inch above C.G. would produce the above 15 units.)

The chart shows why 0-0 setting and 100% C.G. is so touchy. Just an 1/64 adjustment on the stabilizer will produce a change. Even shifting C.G. should be done gradually. You can see why on such models the wing and stabilizer should be well fastened down to prevent shifting, and so upset the balance.

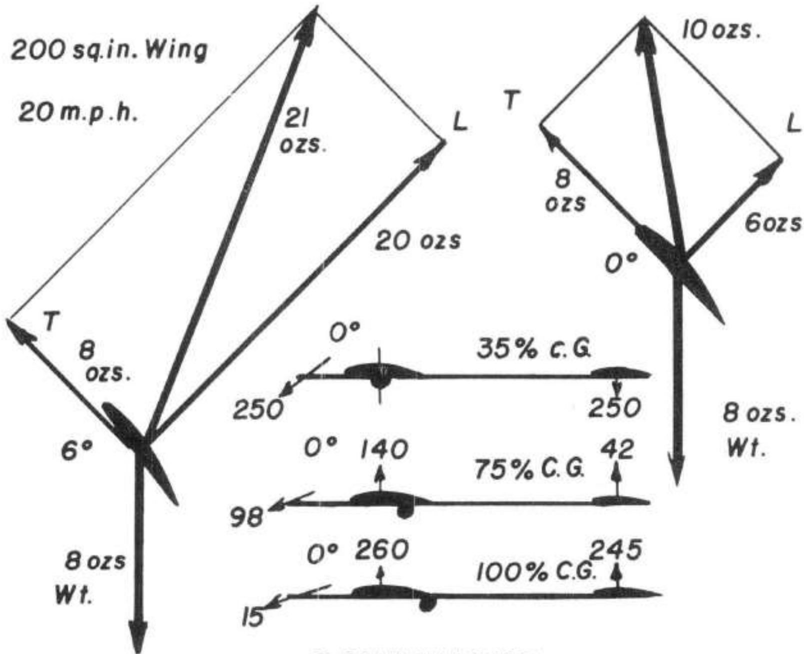
HIGH POWER AND HIGH LIFT

When we use as much power as we do now, we naturally find that we have fast models. And when a model moves fast, it develops more lift than is needed. For example: A 200 sq. in. Clark Y wing, set at 6° angle of attack, will lift 8 ozs. when flying at 12.5 m.p.h. If the speed is increased to 20 m.p.h. the lift will be 20 ozs. However, the model needs only 8 ozs. of lift from the wing to stay in the air. Since the model is trimmed to glide at 6°, we must do something to reduce high lift during power flight.

To clarify the situation, let us diagram the problem. We will assume that the thrust is 8 ozs. and that the model flying in a 45° climb. Placing our forces as shown, we obtain a resultant of 21 ozs. with which to counteract the 8 ozs. weight of the model. It should be obvious that something will happen. And that something does happen in form of looping.

If we could somehow reduce lift to 6 ozs., while the model is flying at 20 m.p.h., we would obtain a balanced condition. See diagram. Note how we now have only 10 ozs. of upward force, and that the thrust contributes a great portion of this force.

The next question is: How to make the wing produce only 6 ozs of lift while flying at 20 m.p.h.? The obvious answer is to reduce its angle of attack during the power portion of the flight. If we use a thin airfoil, like Rhode St. Gense 28, we would find that it would lift about 6 ozs. at 0° while moving at 20 m.p.h. How to bring about this change from 6° to 0°, is the problem. We could use gadgets and stuff. Or we could use downthrust.



DOWNTHRUST

We have shown how it is possible to bring the wing to lower angles of attack by helping the stabilizer have greater force about the C.G. The only trouble is that models having C.G. at 35% and 70% require more downthrust than we can apply within reason. But the 100% C.G. model can be very easily influenced. To bring it to 0° angle of attack, we need thrust force of 15 units according to the chart. In actual practice, it may be more or less.

Once the wing is operating at 0°, we've actually achieved a balanced condition, and the power flight is smooth and fast. After all, by bringing the wing to 0° to obtain 6 ozs. of lift, we also decreased its drag over 100% and moved the wing into its highest L/D condition.

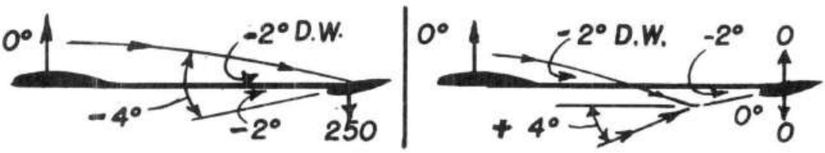
There is more to this 0° angle of attack business than you think. Your models actually try to move automatically into 0° position through a process on which we stumbled and call CIRCULAR AIRFLOW. (Complete history of its discovery will be found in the other book.)

CIRCULAR AIRFLOW

The thrust adjustments, to bring the wing into lower angles of attack, can be easily made on rubber powered models which have the C.G. close to the thrust line. But on standard pylon models, the C.G. is always above the normal thrust line, and too close to the engine to have its thrustline pass over the C.G. without excessive downthrust. Besides, we know that most pylon models fly in almost complete disregard for this "thrustline above the C.G." requirements. Something else must be bringing the wing into lower angles of attack. Something does just that. And that "something" is the CIRCULAR AIRFLOW.

Before we talk about the Circular Airflow, we would like to show that it is possible to bring the wing into 0° angle of attack by, somehow, increasing stabilizer's angle of attack during the power flight. This, of course, must be done without changing the wing's setting. The exact change required can be found by checking the Pitching Moment chart.

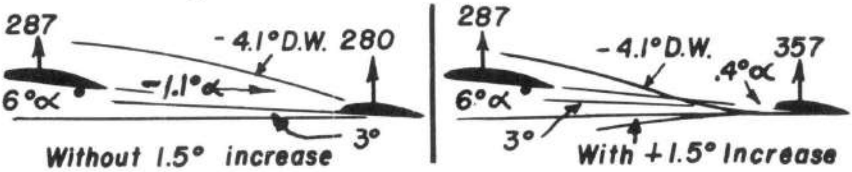
CONDITION 35% C.G.: If we were to place the wing at 0° angle we find that the stabilizer would be –2° to the base line. Normally, and according to the chart, this would mean that the stabilizer would have a download which would tend to increase the wing's angle of attack. The exact angle of attack would be –4°. We have –2° from the setting below the baseline, and we obtain another –2° from the downwash. To cancel out the stabilizer's force, we must introduce 4° of positive airflow. We made few diagrams, showing the airflow, which shows how this 4° positive airflow makes the stabilizer have 0° angle of attack. With the stabilizer at 0°, the wing is in balanced condition because the pivot point is on Center of Wing's Lift.



CONDITION 70% C.G. It is a bit easier, figuring the change required for the 70%. The wing has a force of 140 units when it is flying at 0°. We look at the chart and see if we have a 140 unit force value on the stabilizer side. There is nothing in the exact number, but if you know how to interpolate, you will find it between 127 and 161 units. We did some calculating, and found that, if the angle of attack on the stabilizer was –3.5°, it would generate 140 units; enough to balance the wing with wing at 0°. The chart shows that when wing is at 0° the stabilizer is at –5°, and that it has a force of 42 units. If we were to "increase" this angle of attack by 1.5° so that the stabilizer would be at –3.5°, we would balance the wing with the new stabilizer force of 140 Units. So, by increasing the stabilizer's angle of attack by 1.5°, we bring about a balance, with wing at 0° and stabilizer at –3.5°.

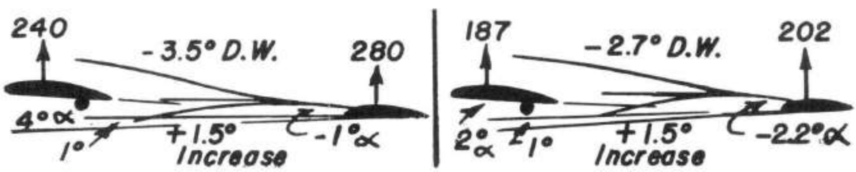
BRINGING WING FROM 6° TO 0°

Say that the wing is at 6°, and the model is in a glide balance, what happens when we introduce the above 1.5° of increase to the stabilizer's angle of attack? This is like saying that now the wing is at 6° and the stabilizer at .4° (–1.1° setting plus 1.5° = .4°). The nearest reading we have to .4° is on the 8° line. On this line the

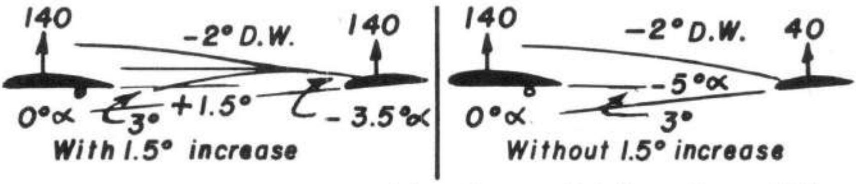


stabilizer has .2° angle of attack and a value of 357 units. The "unbalance" would be 287 units for the wing and 357 units for stabilizer. It is obvious that the stabilizer will swing the wing into lower angles.

Let us stop the movement at 4°. The stabilizer, which would normally have –2.5° angle of attack, now has –1.0°. And it develops 280 units, still too much for the 4° wing's 245 units. The stabi-

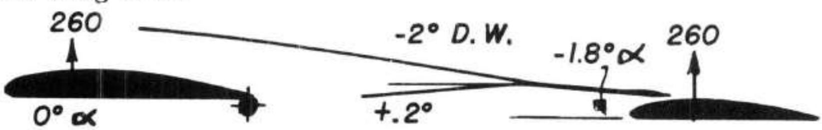


lizer keeps on forcing the wing into lower angles. Stopping at 2°, the normal –3.7° for stabilizer should be changed to –2.2°. The stabilizer, at this angle, still gives more force than at –2.5°, for which we have force value of 187 Units. Therefore, the stabilizer keeps on forcing the wing into lower angles. And at 0°, the balance, which we have determined at the beginning, occurs.



You can now see that a positive change of 1.5° on the stabilizer, brought the model from a 6° position to 0°. On the 35% C.G. position, 4° of angular change was required for the same job.

CONDITION 100% C.G.: Checking the Pitching Moment Chart at 0°, we find that wing develops 260 units, and the stabilizer 245 units. The result is that the wing will try to bring the model into higher angles of attack, as it is supposed to do. To bring about a balanced condition at 0°, the stabilizer must also have 260 units. This 260 Units value can be found between 0° and 1° as the chart shows. By interpolating for the exact angle, we find it to be –1.8°. At –2°, the stabilizer is unable to balance the wing, but it can do so at –1.8°. We can see that a positive change of only .2° on stabilizer's angle of attack is required to balance the wing at 0°.



W.A.	W.C_L x W.M. = W.F.	D.W.	S.A.	A.S.A.	S.C_L x S.M. = S.F.
0	.45 x 650 = 260	2°	0	-2°	.245 x 1000 = 245
A change of +.2° on Stab only			0	-1.8°	.260 x 1000 = 260
1°	.47 x 650 = 310	2.3°	1°	-1.3°	.295 x 1000 = 295
2°	.54 x 650 = 350	2.7°	2°	-.7°	.34 x 1000 = 340
3°	.62 x 650 = 403	3.1°	3°	0	.393 x 1000 = 393
4°	.7 x 650 = 455	3.5°	4°	.5°	.45 x 1000 = 450
5°	.76 x 650 = 494	3.8°	5°	1.2°	.49 x 1000 = 490
6°	.82 x 650 = 533	4.1°	6°	1.9°	.533 x 1000 = 533

We could show how it is possible to start with the wing at 6°, and bring it down to 0°, by increasing the stabilizer angle by only .2°. However, the mathematical balance is very touchy. And we would be playing with very fine points of favoring bits of lift for one side or the other during the demonstration. Take our word for it, the wing will drop down to 0° if the stabilizer is given .2° when the wing is at 6°.

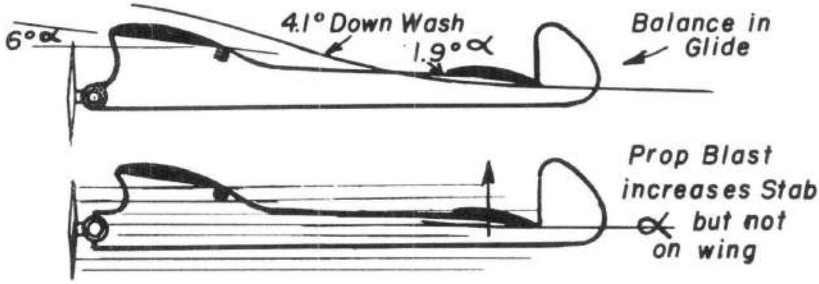
TOUCHY SETTING FOR 100% C.G.

Anyone trying to adjust models, having C.G. at 100% and 0-0 setting, will know that such models are very touchy. Now you know why; .2° change means less than a 1/64th in a 5″ chord. So, be sure to carry thin paper strips for incidence adjustments. And also realize how important it is to fix wing and stab solid to prevent shifting, and so changing the balance.

SLIPSTREAM BLAST ON ANGLED STABILIZER

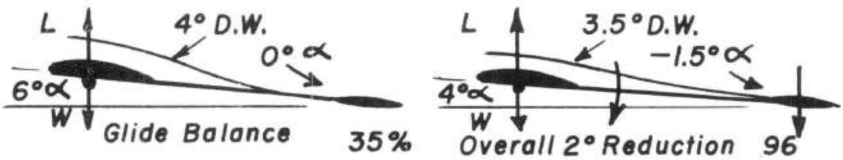
The next question is: How to increase the stabilizer's angle of attack during the power flight without using thrustline?

For gas models, we worked up one possible solution. The idea was to have the prop slipstream blast on the stabilizer, which is set at as high angle as possible to the slipstream. The basic layout is shown. Note that the prop should be below the wing. This is easily done with pylon design. If slipstream passes over the wing, higher downwash angles will result; something that would cancel out all that we are trying to do.

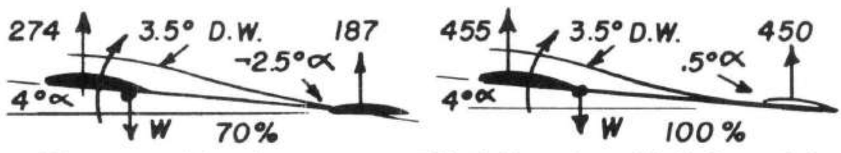


EXPLAINING LOOPING UNDER HIGH POWER

At the beginning of the book, we mentioned how a decrease in the "overall" angle of attack produces looping effect. This can be seen by looking at the Pitching Moment Charts. Say that the "overall" angle of attack was reduced from 6° to 4°. Looking at the 4° line on the 35% C.G. Chart, we find that the stabilizer has a download of 96 units. This "download" will try to make the model point upward, or towards the looping possibilities.



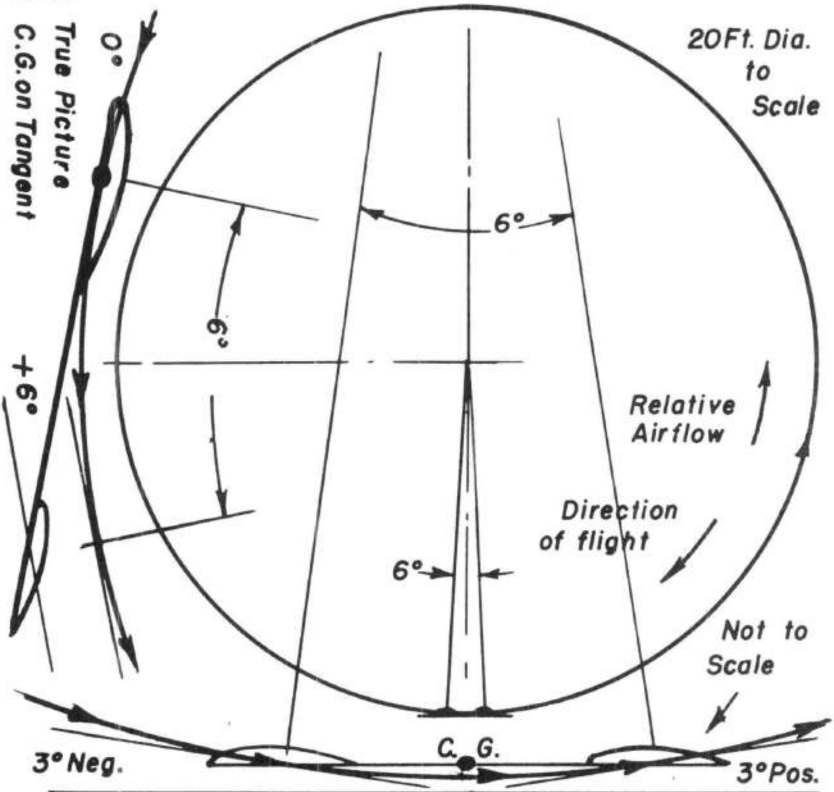
W.A.	W.C_L	D.W.	S.A.	A.S.A.	S.C_L x S.M. = S.F.
3°	.62	3.1°	1°	−2.1°	−.21 x 638 = −135
4°	.7	3.5°	2°	−1.5°	−.15 x 638 = −96
5°	.76	3.8°	3°	−.8°	−.08 x 638 = −51
6°	.82	4.1°	4°	0	0 x 638 = 0



The same thing happens to 70% C.G. and 100% C.G. models. Except that at lower angles than 6°, the wing has greater force. Since it is in front of the C.G., the wing will "nose" model upward into looping possibilities. The idea could be carried on in more detail. However, the main fact to remember is that high speed produces high lift if angle of attack is held to 6°. If lift is high, the "over all" angle of attack will be decreased. This will bring about looping or zooming conditions in which the Circular Airflow will operate.

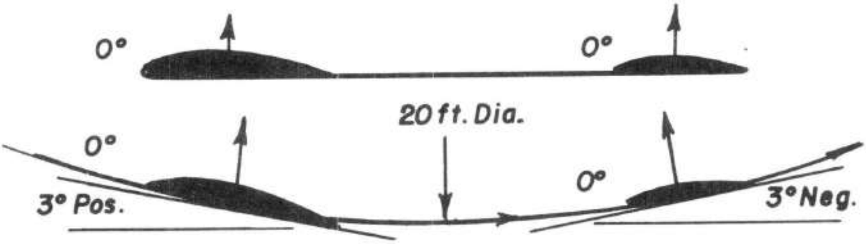
EXPLAINING CIRCULAR AIRFLOW

The automatic action which increases the angle of attack on the stabilizer without doing the same thing on the wing, can be best understood if we were to assume that our model is flying in a vertical bank. As the model flies around in a circle, along the diameter shown, a stationary air molecule would first hit the wing on the upper surface, and as the stabilizer came along, it would hit the stabilizer on its lower surface. To us, this has same meaning if we were to say that the wing received a negative angle of attack and the stabilizer a positive angle of attack. This means that the lift is decreased on the wing and increased on the stabilizer.



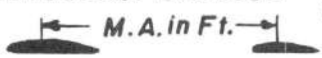
To clarify the situation, let us assume that the circle is 20 ft. in diameter, or 60 ft. in circumference. This means that every foot arc would be subtended 6°. If we were to draw tangents at the tips of such arcs, we would find an angular difference of 6° between the arc tips. Supposing we were to place a model, having 1 ft. moment arm, in the arc position and see what the tangents will do. See diagram. Note that the wing now has a 3° negative angle of attack and the stabilizer 3° positive.

Next supposition: A model, which glided well in a straight flight when both surfaces were at 0° to the airflow, can be made to have similar characteristics in the Circular Airflow. This is done by setting the incidence angles so that the wing has 3° positive and the stabilizer 3° negative. If we try to fly this arrangement in a straight path, it would stall like nobody's business. But place it in the above 20 ft. diameter circle, and it will behave normally. See diagrams. Can you begin to see the possibilities of Circular Airflow?



PRACTICAL EXAMPLE: We have the 70% C.G. model, on which we must increase the stabilizer angle of attack by 1.5°, to make it bring the wing to 0°. How to do this? No bother at all; just fly the model in a circle in which the required Circular Airflow Angle will be produced. To find the size of the circle, we developed the following formula:

$$\text{ANGULAR CHANGE} = \frac{360° \times \text{M.A.} \times \text{Bank Angle}}{3.14 \times \text{Dia. of Circle in Feet} \times 90°}$$



The Angular Change is the difference between the tangents at the ends of the arc as shown. Note which factors govern the Angular Change. By increasir g Moment Arm or Bank, the change will be greater. While making the circle larger will decrease the angle.

EXAMPLE: Find diameter of circle required to obtain 1.5° Angular Change for the 70% C.G. model while it is in a vertical bank. The M.A. is 19" or 1.5 ft. Therefore:

$$1.5° = \frac{360° \times 1.5 \times 90°}{3.14 \times \text{Dia.} \times 90°} \qquad \text{Dia.} = \frac{360° \times 1.5 \times 90°}{3.14 \times 90° \times 1.5°} = 120 \text{ Ft.}$$

So, if we make our model to fly in a 120 ft. circle with the wing in a vertical bank, the stabilizer will automatically receive 1.5° increase in its angle of attack, and bring the wing from 6° to 0°.

The above formula can, of course, be reduced to a smaller group. We just wanted to show what factors we used in case we did something wrong. The condensed version can be written as:

$$\text{ANGULAR CHANGE} = \frac{1.33 \times \text{M.A.} \times \text{Bank}}{\text{Dia. of Circle}}$$

To bring about 4° change for the 35% C.G. model, a 45 ft. circle would do. While a .2° change on the 100% C.G. model would require 900 ft. (As we said before, .2° is cutting it rather close. In practice, this would mean an impossible design. Maybe you had one, and you know what we mean.)

$$Dia. = \frac{1.33 \times 1.5 \times 90^\circ}{4^\circ} = 45' \qquad Dia. = \frac{1.33 \times 1.5 \times 90^\circ}{.2^\circ} = 900'$$

CIRCULAR AIRFLOW IN MODERATE BANK TURN

It should be evident that when a model is in a vertical bank it is not going to stay up long. We must bring it to a more horizontal level. Suppose we see what happens if we place the 70% C.G. model in a 30° bank, a good compromise. (A 10 ozs. of lift is converted into 8.6 ozs. of vertical lift and 5 ozs. of side force.) The required change is 1.5°. Find diameter of circle:

$$1.5^\circ = \frac{1.33 \times 1.5 \times 30^\circ}{Dia.} = \qquad Dia. = \frac{1.33 \times 1.5 \times 30^\circ}{1.5^\circ} = 40'$$

Notice how the diameter of the circle dropped down to 40 feet when the wing is banked 30°. This is natural. As the wing moves from vertical to horizontal, it automatically decreases the value of the Circular Airflow Angles. When the wing is horizontal, no Circular Airflow is possible. So, as the bank is decreased from the vertical, we must keep the value of the Circular Airflow by decreasing the size of the circle.

Our 35% C.G. model needs a 13.3 foot circle if we had it flying at 30° bank. While the 100% C.G. model will require about 300 feet circle for its .2° change.

$$Dia. = \frac{1.33 \times 1.5 \times 30^\circ}{4^\circ} = 13' \qquad Dia. = \frac{1.33 \times 1.5 \times 30^\circ}{.2^\circ} = 300'$$

CONCLUSIONS

What do you think of the idea? Can you check any of your flying experiences with this theoretical work? Perhaps, if we were to try flying a high powered 35% C.G. model, you would get a better idea how this Circular Airflow behaves.

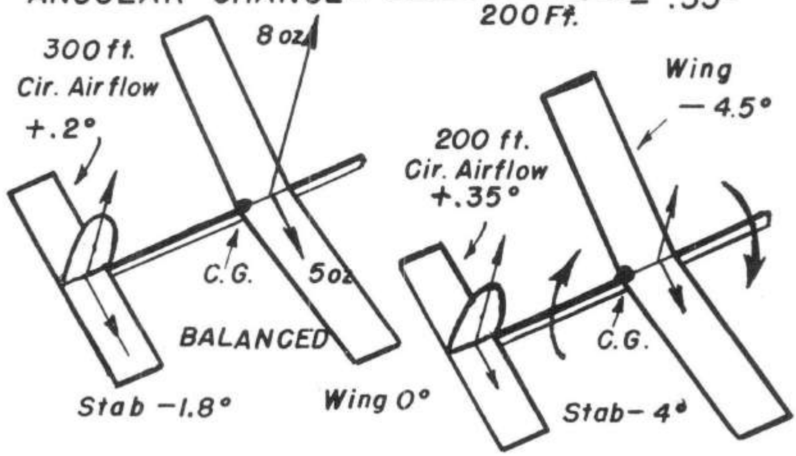
When we think of it, the models have actually been using the above Circular Airflow Action ever since the beginning. You can judge from experience, if your models had C.G. closer to 35% than 100%, the models had a tendency to develop tight power turns or circles. What actually happened, is that the models had to find a balanced position, in which the lift production is equal to that the models needed. Sometimes we wonder at the gradual development of designs which automatically take care of so many things, without us knowing anything about them.

CIRCULAR AIRFLOW AND SPIRAL DIVES

To explain how CIRCULAR AIRFLOW can produce spiral dives, we have to make the following assumption: Our 100% C.G. model is flying in a 300 ft. circle, with the wing banked 30°. According to our assumption, the wing is now flying at 0° angle of attack, as we gave the stabilizer the required .2° increase. Let us assume that the airfoil we are using on it is lifting 10 ozs., which, when angled, give us 8 oz. of vertical lift and 5 oz. side lift. Now, 8 ozs. is just enough to keep the model in a level flight. Any reduction in the lift would make the model come down.

For some reason, we want to make the model have a tighter turn, about 200 ft. in dia. To obtain this circle, we set the rudder so that the wing banks 35°. What will be the Angular Change?

$$\text{ANGULAR CHANGE} \doteq \frac{1.33 \times 1.5 \times 35^\circ}{200 \text{ Ft.}} = .35^\circ$$



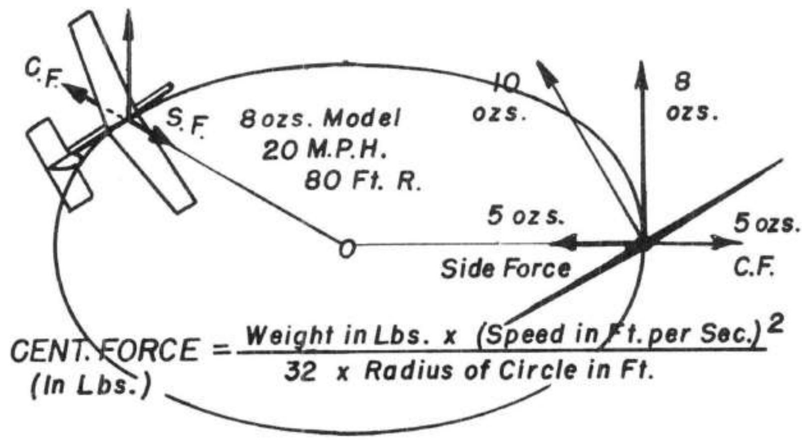
When the stabilizer has an increase of .35° on this 100% C.G. model, we should expect drastic results. Note how only .2° was required to bring the wing from 6° to 0° where it developed 8 ozs. of vertical lift. The extra .15° might bring it to −4.5°. And how much lift do you think it can develop at this angle? Practically none. Now, imagine a model in a bank; then suddenly remove the lift from the wing, but leave it on the stabilizer. What do you expect will happen? You are right, the nose will drop down, and the action will be similar to spiral dive which we usually attribute to Spiral Instability.

EVERY MODEL HAS A DEFINITE MINIMUM CIRCLE

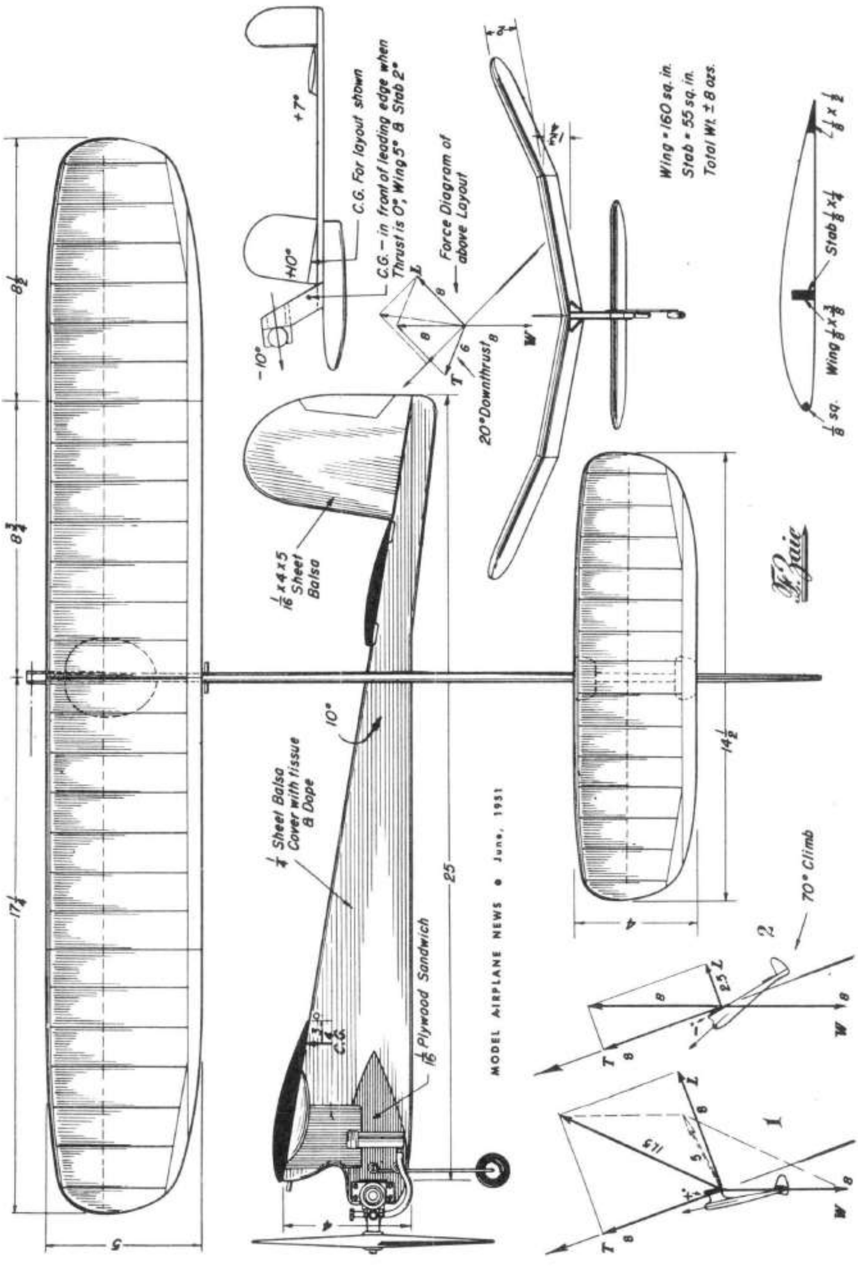
We could go on, and write another book, just on this Circular Airflow subject. But we hope you have the idea. If you try to tighten up a model beyond its safe minimum circle, the Circular Airflow will backfire and give you spiral dives. Whenever your model tends to spiral dive, open up the circle, if at all possible. If it then has a tendency to loop, use downthrust. Usually, the models that will have looping tendencies will be in the forward C.G. class, and they will be able to take tighter turns than the 100% C.G. just covered. Just realize that every model has a minimum size circle. Once you find it, do not try to make it smaller. The only way you can make it smaller is by actually using UPTHRUST. This will counteract the higher force of the stabilizer. It seems funny, using upthrust, but according to the theory, such is the case. We never tried it. We just made it up as we realized what goes on. Hence, on the 100% C.G. models, it may be a good thing to have thrustline below C.G.

FACTORS WHICH DETERMINE SIZE OF CIRCLE

Size of the circle is determined by the requirements of the Angular Change, which is developed by the size of the circle and the bank of the wing, and the Centrifugal Force. This force is determined by the following formula:



The trick here is to make sure that whatever circle you may be using, the side lift of the wing should equal the Centrifugal Force; and that this particular circle must also develop the required Angular Change. We have two variables which must be satisfied. The only way to do this is to make up a table, and then pick out the nearest combination. We made such a table, and it is in the other book. Out of possible 100 combinations, a model may be able to use only one. For example: 8 oz. model, banking at 30° and flying in an 80 ft. circle, at 20 m.p.h., has to develop 8 ozs. of vertical lift to balance weight of model, and 5 ozs. of side force to balance the C.F. The trick is to have the Angular Change be such, that the wing will lift 10 oz. which can be resolved into 8 oz. lift and 5 oz. side force. So, you can see that it could become complicated.



C.G. For layout shown
C.G. – in front of leading edge when Thrust is 0°, Wing 5° & Stab 2°
Force Diagram of above Layout
20° Downthrust
$\frac{1}{16}$ x 4 x 5 Sheet Balsa
$\frac{1}{4}$ Sheet Balsa Cover with tissue & Dope
$\frac{1}{16}$ Plywood Sandwich
70° Climb
Wing = 160 sq. in.
Stab = 55 sq. in.
Total Wt. ± 8 ozs.
Stab $\frac{1}{8}$ x $\frac{1}{4}$
Wing $\frac{1}{8}$ x $\frac{3}{8}$
$\frac{1}{8}$ sq.
$\frac{1}{4}$ x $\frac{1}{2}$
17$\frac{1}{4}$
8$\frac{3}{4}$
8$\frac{1}{2}$
25
14$\frac{1}{2}$
+10°
+7°
−10°
10°

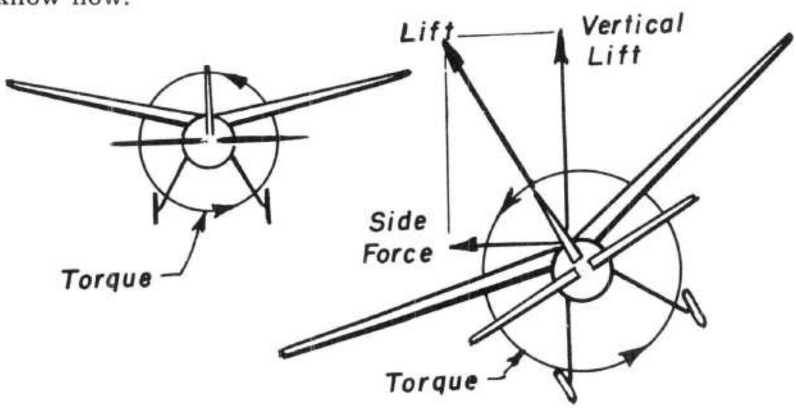
SPIRAL STABILITY

A model is in a constant state of "shimmy" to adjust itself to ever-changing conditions. Unless the various part of the model are in a harmonious combination, we may expect expensive trouble. And here is where Spiral Stability comes in.

TORQUE, SIDESLIP AND DIHEDRAL

Perhaps, the best way of introducing you to Spiral Stability is to show how the dihedral controls the torque. Working with known forces gets you out of that hazy and nebulous "technical talk" feeling that you believe should be taken to heart by the other fellow.

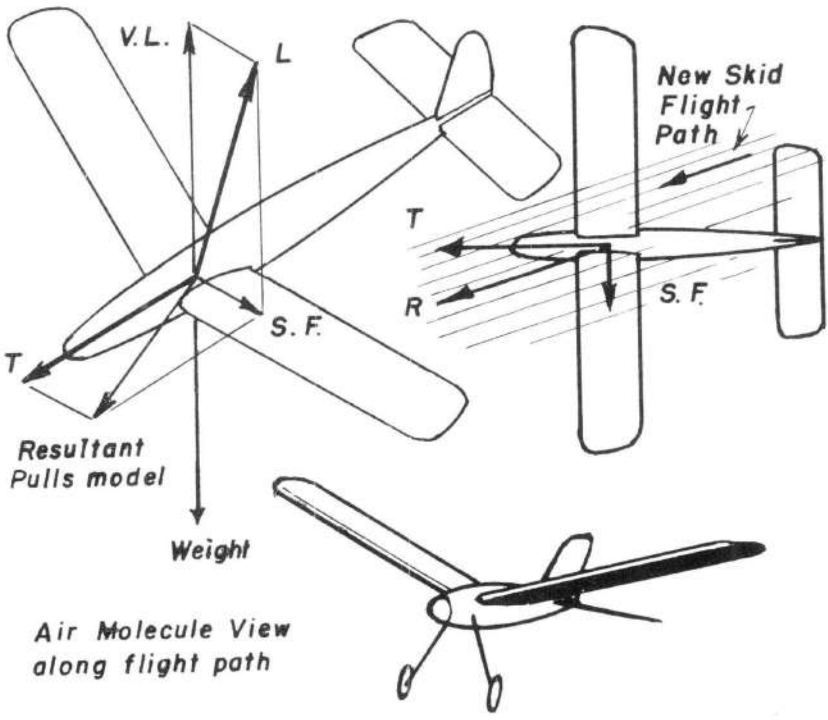
Torque problems are still with us, although they may not be so evident as they used to be in 1935. At that time, many models had very little dihedral and you could see torque take over and swing the ships into left spiral dives. As you will see, torque is the "force" which sets in motion the flight pattern your particular model will make once it is released. It does not determine this pattern, mind you; it is the force that carries through to a conclusion whatever the aerodynamical design dictates. Do not blame the torque for your troubles. You know it is there and you are supposed to know how to make it help you. It can be done, if you know how.



Looking from the rear of a model, we find that the torque force will try to swing the model into direction shown. As the model swings into this direction, the lift force also swings with the model. Once the basic lift force swings beyond the vertical position, it tends to pull the model to one side. So, here we have a condition in which the propeller is pulling the model forward and the wing, besides holding it up, also wants to pull it to one side. Breaking up this basic lift force, which is now angled, into its lifting and side pulling components, we have the force diagram shown.

HOW SIDE SLIP FORCE IS DEVELOPED

The perspective of the forces involved is shown. Note that lift and weight balance each other, but that there is no balance for the side pulling portion of the lift force. Since the thrust or forward moving force is so much greater, we should not expect a side force to perform some sort of a side step which we could see. Its actual effect on the model can be determined by making a force diagram of the thrust line and the side force. The resultant is the direction into which the model will try to move. You can see that it is a compromise between thrust and side force. The main thing to remember, though, is that the fuselage will remain on the thrust line axis and that it will not move "head on" into the new direction, but will move in a "skidding" fashion. This is the most important phase of our work. Once you can see that it is possible for the model to move in a "skidding" fashion, the rest is easy.



Just how does this new motion look to the air molecules? For this view, we should look at the model from the front along the resultant line. The view is shown. It is a compressed side view. — It is from this view that we can predict exactly what the model will do as far as spiral stability is concerned. But you will have to know what to look for. To help you in this, we have worked up a visual demonstration with gliders.

SPIRAL STABILITY DEMONSTRATION

We are happy in developing the following demonstration showing reaction to torque of different side area distributions and dihedrals. It saves us so much trouble in trying to put arm motion into words and sketches. Besides, you can always check up on us by making the models shown and going through the test yourself. We are sure that, after you see them behave as they do, you will want to know why they seem to be so contrary to normal expectations.

TEST GLIDERS

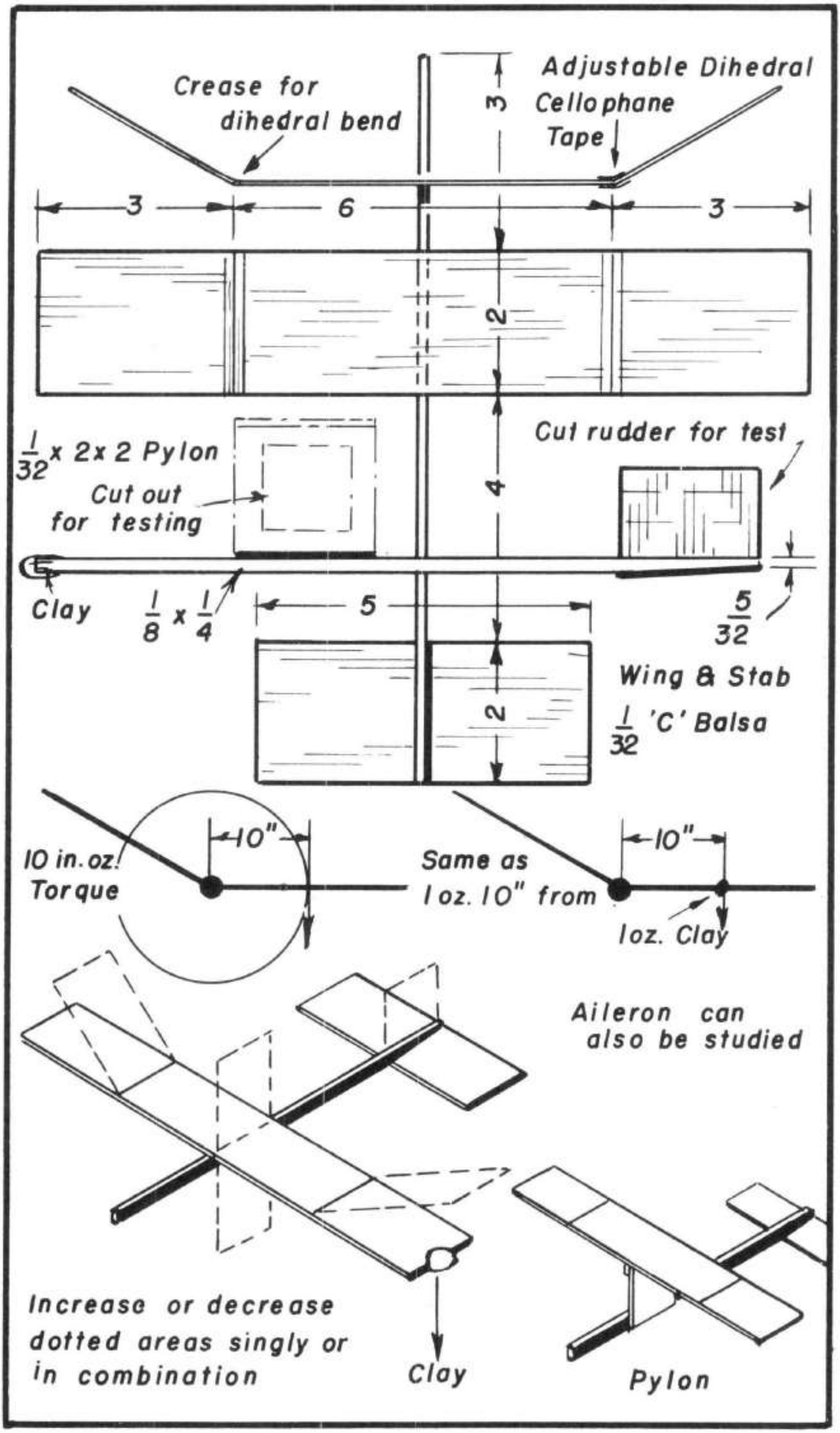
Test gliders are very easy to make. We made two, one with the wing on the fuselage, and the other on 2 x 2 pylon. We changed the dihedral angle by creasing the balsa and using cellophane tape to keep the desired angle. If you like, you can make a model for every dihedral angle you wish to investigate. This is a good idea if you would like to have a demonstration before a club group. Rudders can be cemented and taken off easily enough, especially, if you use "Testor A" cement. Be sure to use only flat "C" grain 1/32 balsa sheets, so that you will not have warps to counteract what you are trying to do.

While we were developing this particular demonstration during 1938, we wondered how we could simulate torque without using motor and prop. Then came the idea of using weights on tips. Weight on tip shifts C.G. position from center line outwards, requiring more lift on that side to preserve a level attitude. Torque may not shift C.G., but it does tend to force one wing down. To make this wing come up, it must have greater force than the other. As far as the wing is concerned, the actions of tip weight and torque are similar. The result of torque and/or tip weight is to introduce side skid conditions.

Altogether, we made about 50 individual tests. Most of them are individually described and analyzed in the other book. However, you should have no trouble in making the tests yourself. Start with wing level, and use no rudder. Add clay to left wing tip and see how torque reacts on different arrangements. Then add rudder. Start with a large size, and then trim to nothing, to see the effect of different rudder areas.

To check on the effect of side area, above or below the C.G., just cement large fins, about C.G., and watch what happens. Be sure to add clay to left wing tip to obtain torque reaction. You will be surprised at the result.

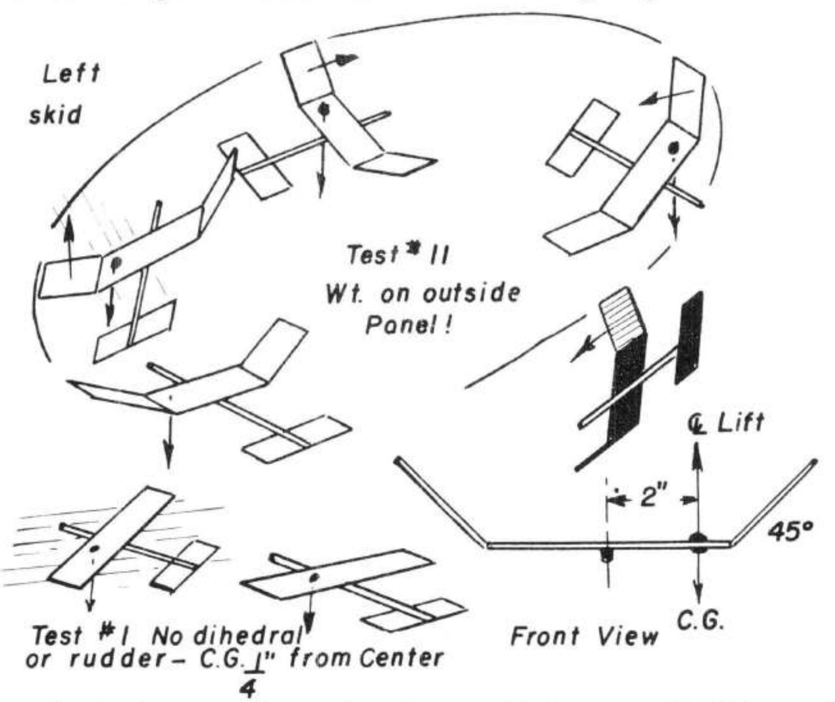
After you are through with level wing tests, start with 10° dihedral and gradually work up to 45°. Be sure to add and remove rudders as you go along. Also increase and decrease clay weight. The entire test took us about 12 hours. Next day we felt as if we had climbed a mountain. Although, the highest bit of climbing we did do, was to the top of the radio cabinet.


Crease for
dihedral bend
3
Adjustable Dihedral
Cellophane
Tape
3
6
3
2
1/32 x 2 x 2 Pylon
Cut out
for testing
4
Cut rudder for test
Clay
1/8 x 1/4
5
5/32
Wing & Stab
1/32 'C' Balsa
2
10"
10 in. oz.
Torque
Same as
1 oz. 10" from
10"
1oz. Clay
Aileron can
also be studied
Increase or decrease
dotted areas singly or
in combination
Clay
Pylon

We made one test which we would like to describe in full. It happened with a 45° dihedral test. We had enough weight on its left tip to bring the C.G. 2″ unto the left wing. No rudder was used.

EXPLAINING TEST #11

In Test #11, we have 45° dihedral with C.G. 2″ from center line. The action of the 45° dihedral, in counteracting this C.G. position. is very positive and definite in swinging the model into right turn and final spiral dive. It is so typical of present day models that it calls for greater details, especially, if compared with Test #1 when only 1/4″ C.G. shift forced the model into a left skidding turn in contrast to the above right spiral dive.



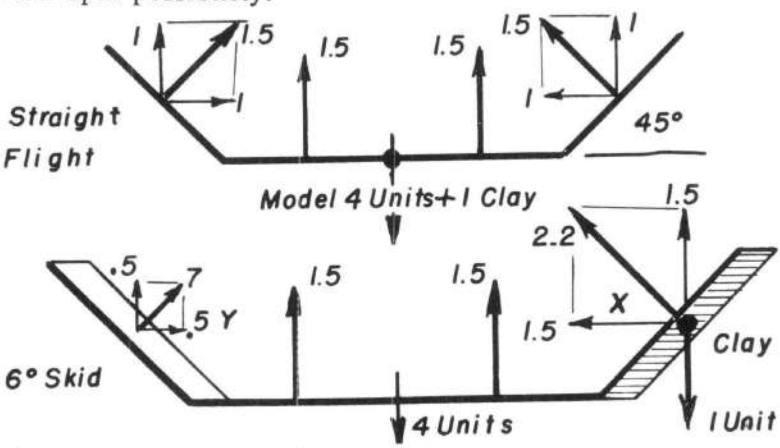
Analyzing the above situation, we find that with C.G. at 2″ point, the left wing will have to develop almost enough lift to carry the entire model. This calls for an exceptionally large skid angle. A typical glide path of this model was for the model to drop fast with left wing low. As it picked up speed, the left wing obtained the required side-drift airflow and lifted itself above the horizon and into a bank. We did not have enough altitude to observe more than half a circle, but we know what happens under power, once the spiral dive shows its sign. That the wing must have had a large side airflow angle is shown by Test #13 where a 2 x 3/8 rudder was required for straight flight with skidding attitude.

The peculiar part of this test is, that without tip weight, the model had a straight glide without rudder. Of course, any attempt to make it turn would result in a spiral turn. When you are duplicating this test, note the action of the left wing. You will see it actually lifting all that clay, and eventually develop into a right spiral dive. If you ever had doubts about the torque, and how it develops side skid, this should be convincing performance. —Also, as shown by Test #13, a rudder, large enough, will correct this right spiral dive by making the wing maintain a definite skid angle, although the model may be flying straight ahead.— It will be worth your while to try this experiment.

SPIRAL DIVES WITH HIGH POWER AND LARGE DIHEDRAL

We have been trying to find the cause of right spiral dives for a long time. We found one possibility in the Circular Airflow. While working on Spiral Stability, we uncovered another possibility. — After you have seen what happened in Test #11, it may be easier to understand.

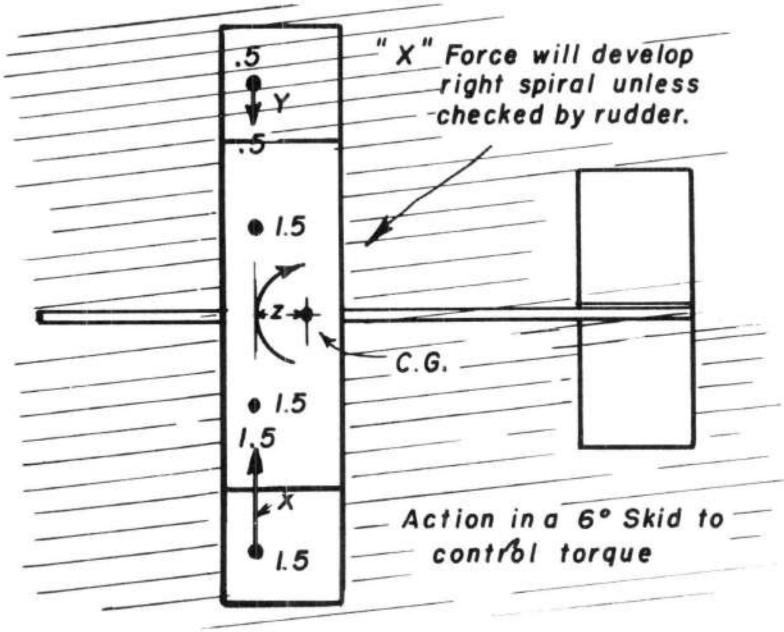
To present the situation in true light, we must assume certain mathematical factors. Let us suppose that the model weighs 4 Units, and the tip torque-clay weighs 1 Unit. This gives us a total of 5 Units. If we place this weight on center of the model over the C.G., the wing loading, on a 45° tip dihedral wing, will be as shown. The center panels carry 1.5 Units each, while the tips, due to their angulation, carry 1 Unit each. Note that basic lift for the tip is 1.5 Units, and that side forces equal vertical forces of 1 Unit. Keep your eyes on these side forces. They hold the key to our spin possibility.



The next step is to shift our 1 Unit of clay weight under the left wing as shown. This means that, if we want to maintain a level flight, the left wing will have to lift 1 Unit more than the other. This is done by making the model skid.

When the model skids, the angle of attack will change for the two tips, but not for the center sections. The right will have a decrease, and left an increase. The balance of forces will now be as shown. The total vertical lift is still the required 5 Units, and we seem to have accounted for all of our requirements. But have a look at the side forces.

The right wing generates only .5 Unit of side force, while the left produces 1.5 Units. What effect do these different values have on the model? This can be best seen by consulting the plan view of the model.

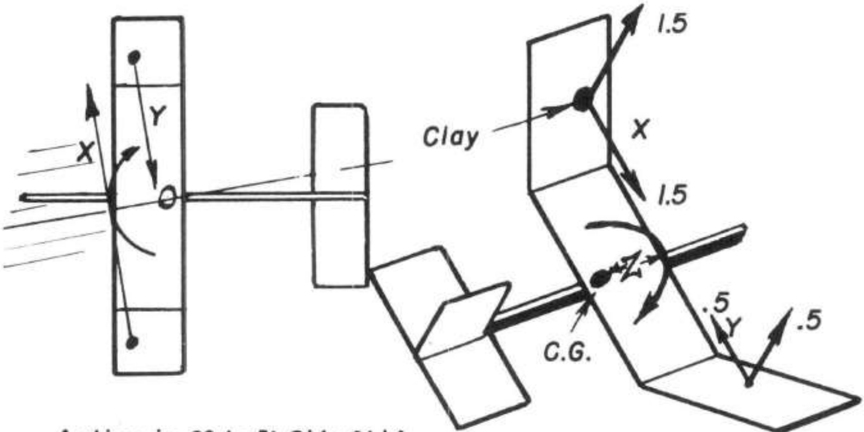


Note the forces. All vertical ones are shown as dots. But side forces are in their true light. We labeled them "X" and "Y". Also note the position of the C.G. It seems to follow practice by having it near the trailing edge.

It should be evident that "X" force and "Y" forces are not equal. "X" forces is greater by 1 Unit. Now, this Unit, working on the moment arm "Z", will try to turn the model into a right turn direction. Note that this force is developed by the dihedral action in a side skid. It is not present when there is no side skid.

If there is nothing to stop the "X" force, it will tend to swing the model into higher side skid angles. As it does so, the lift of the left tip will be increased, and of the right, decreased. It could be that the left will acquire a total lift of 2 Units, while right is reduced to zero. Test #11 showed what happened: Left wing developed enough lift to bring the heavy clay up, and over, into a right spiral turn.

In the above case, we did not present the picture in complete light. As the model moves in a skid, the view of forces is as shown. Note that "X" force has a greater moment arm, and "Y" has shorter. Everything seems to be trying to bring about the right spiral dive.



Action in 6° Left Side Skid
If rudder is too small, Left wing will swing model into right spiral dive.

SPIRAL DIVE AND CIRCULAR AIRFLOW

Remember what we said about tightening a circle below its minimum? Well, could it be, that the high dihedral, when not checked by adequate rudder area, tends to develop tighter turn. When the circle becomes smaller, the Circular Airflow comes in. If the model is of 0–0 variety, only a slight change is needed to bring about a complete loss of lift. Think about the combination of these two spiral dive possibilities. We think that they explain the action of the spiral diving models while under power.

LARGE DIHEDRAL AND SMALL RUDDER

Models having large dihedrals, mounted on high pylons, and also having small rudders, are idea subjects for the above spiral dive possibilities. Such a model may be perfectly fine in a glide, or under low power. The side areas may actually be in balance; after all, the dihedral effect is not felt in a glide. But what is good in a glide, or under low power, may not be so good under high power. As soon as the model skids to obtain high torque control, the dihedral forces may easily overcome the small rudder. The result is the usual "end of a perfect day."

All this means that we must design the rudder large enough so that it will keep the wing under control at all times; and not use larger dihedral angle than needed.

TORQUE CONTROLS DIHEDRAL ANGLE

The only logical torque control is the use of dihedral in a side slip. Tabs, and the like keep their setting during the entire flight, and they may spoil the glide setting. But dihedral is an automatic control. It only works when needed, and then only as much as required. So, to find how much dihedral a model needs, we must know the torque value of the power used.

According to the reports in the *"Model Aircraft,"* the British magazine, an Atwood Glo-Devil 60 has 90 in. ozs. torque. McCoy 19 has 23 in. ozs. While an .09 engine develops 10 in. ozs.

Rubber power has a story of its own. We all know how the power or torque curve of a rubber motor looks. Well, a fully wound, 16 strands of ¼ Dunlop Black rubber has as much as 80 in. ozs. torque at its peak. Perhaps even more if you have the necessary strength for the last gasp. So, if you are exclusively gas model flyer, feel sorry for us rubber model builders. The boys using Atwood Glo-Devil engine, have it on models of 800 sq. in. or so. While we, with almost identical torque to handle, have only 200 sq. in. —

EFFECTIVENESS OF THE DIHEDRAL

The effectiveness of the dihedral as a torque control, depends on the speed of the model. It should be evident, that if torque is same, the speed will determine the amount of lift developed by the wing. — At 12.5 m.p.h. a 200 sq. in. may lift 8 ozs., but at 20 m.p.h., it may lift 20 ozs. This means that the dihedral has to be almost twice as large on the model moving at 12.5 m.p.h. than for the faster one. We brought out this fact to show that our examples should not be taken for granted as being exactly what is needed. We just want to show you how you can determine the dihedral for yourself, if you know the torque value, lift of the wing and the speed of the model.

CALCULATION OF "V" DIHEDRAL ANGLE

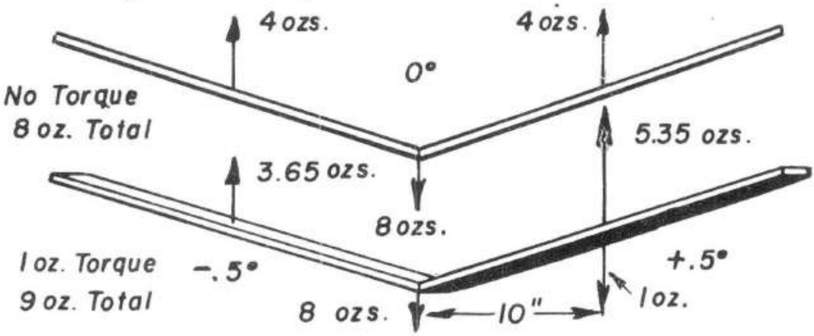
For our first example we will use 10 in. oz. torque value on a 200 sq. in. wing. Speed: 20 m.p.h (8,000 r.p.m. x 75% of 3" P. prop. as a rough check.) Maximum allowable side skid 6°

Having 10 in. ozs. torque on a 40" wing, means that the left wing will have to carry 1 oz. more than the right. See diagrams, showing normal or no torque load, and with 1 oz. load on left.

To take care of this difference, the wing will have to move into a side skid or drift angle, to enable the dihedral to function. To find this drift angle, we must know how much the angle of attack had to be increased for the left wing, and decreased for the right. This is done as follows:

The lift of our wing at 6° is 20 ozs., and zero lift occurs at –6°. Therefore, we have 12° in which a total of 20 ozs. is developed. Dividing 20 ozs. by 12°, we have lift generation of 1.7 ozs. per degree of angle of attack. This is for the total wing. For each wing half, the lift is .85 ozs. per degree. Study this carefully, as it is the base for our calculations.

To find out, how much greater must be the angle of attack on the left wing, than on the right, to produce the required 1 oz. difference of lift, we divide 1 oz. by .85 oz. The result is 1.1°. This means that left wing must have 1.1° greater angle of attack, than the right, to develop this needed extra lift.



DIHEDRAL IN SIDE SLIP

As we know, when the dihedral wing skids to the left, the left side will have an increase of angle of attack, and the right side a decrease. The increase and decrease in the angle of attack depends on the skidding angle, and the dihedral angle. We worked up the following formula which will give us all the answers we need, if we have the necessary data:

$$\text{ANGLE of ATTACK} = \frac{\text{Drift Angle} \times \text{Dihedral Angle}}{90^\circ}$$

In bringing the dihedral into a side drift, we can see that the change of angle of attack of 1° for the left, will mean a change of –1° for the right. The total difference between the two halves would now be 2°. This is a very fine point, and you should try to understand it.

In our case, we have a difference of 1.1°. This means that an overall change of angle of attack should be .55°. Assuming 6° side drift, we have enough known factors to solve the formula:

$$.55^\circ \times 90^\circ = 6^\circ \times \text{Dihedral}$$

$$.55^\circ = \frac{6^\circ \times \text{Dihedral}}{90^\circ} \qquad \frac{.55^\circ \times 90^\circ}{6^\circ} = \text{Dihedral} \qquad \frac{49.5^\circ}{6^\circ} = 8^\circ$$

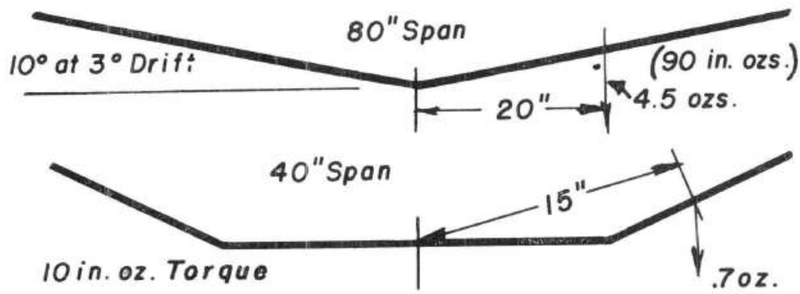
And so, the .09 engine, which develops 10 in. ozs. of torque, needs 8° "V" dihedral in a 6° side drift. (8° equals 1⅝" Dihedral per foot of span under each tip.)

DIHEDRAL FOR 60 ENGINES

To give you an idea how much dihedral the super-powered models need, we will assume that the wing span is 80" and weight 60 oz. and that speed is high enough to give us a lift of 12 oz. per degree for the wing, or 6 ozs. per half. 90 in. ozs. torque on 20" moment arm means 4.5 oz. more lift required from the left wing. Angular difference required is 4.5 ozs. divided by 6 ozs., or .75° Over all angle of attack is .35°. Using the formula:

$90^\circ \times .35^\circ = 6^\circ \times$ Dihedral $\qquad 31.5^\circ/6^\circ = 5^\circ$ Dihedral

About 1" under tip for every foot of span will give 5°. So that there does not seem to be need of dihedrals some may be using. If you want control at lower drift angles, say 3°, the dihedral needed will be 10°. Or about 2" per foot of span under each tip.



TIP DIHEDRAL

Calculations for finding the tip dihedral are similar to those used for the "V". The only difference is that we only have the tips which we can use for torque control. In the "V" dihedral wing, each half carried a load of .85 oz. per degree. So now, the tips will carry .42 oz. each. The force diagrams will be as shown. Note the 15" moment arm. This means that left wing needs only .7 ozs. extra lift for 10 in. ozs. torque. Dividing .7 oz. by .42 ozs. we have 1.6° angular difference requirement, or .8° over all angle of attack. Assuming 6° drift, we have:

$90^\circ \times .8^\circ = 6^\circ \times$ Dihedral $\qquad 72^\circ/6^\circ = 12^\circ$ Tip Dihedral

In a 3° Drift $\qquad 72^\circ/3^\circ = 24^\circ$ Tip Dihedral

On the 40 in. ozs. torque, the tip dihedral needed is 44°.

POLYDIHEDRAL

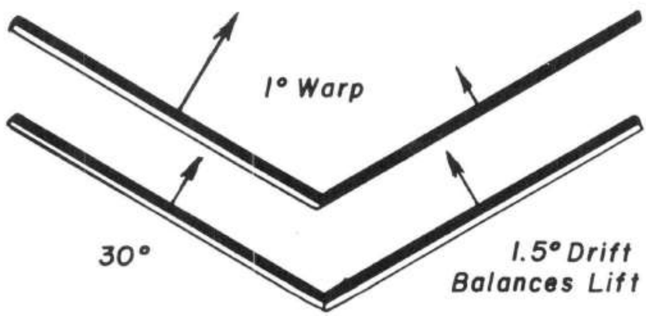
Effect of polydihedral is similar to Tip Dihedral. The center portion will have very small torque control. Its moment arm is too small to have much effect. Calculate for tip dihedral; then reduce tip dihedral slightly, and give center dihedral half of the resultant tip dihedral.

DIHEDRAL ANGLE AND WARPS

Dihedral is a wonderful thing. It covers so many mistakes with a generous coat of plus-and-minus. Take warping, for an example. Say that the right wing has a warp equal 1° of plus incidence. If the wing was flat, the only solution would be to remove the warp. But if you have a 30° dihedral, just a bit of side drift is needed to cancel out our poor work. 1° difference means .5° in over all angle of attack in our calculations. So, how much drift will be needed to correct 1° of warp? By formula:

90° x .5° = Drift x 30° Dihedral   45°/30° = 1.5° Drift.

To correct the above warp on the right wing, we need 1.5° Drift to the left, to make both wings have similar angle of attack or lift. To provide this 1.5° drift, we set the rudder slightly for the right turn. And so, just by a slight twist of rudder a warped wing is made usable through the courtesy of dihedral action.



RUDDER AREA

We have shown how important it is to have the rudder area large enough, so that it will not allow the wing to bring the model into drift angles higher than 6°. The reason we use 6°, is that rudder might stall at higher angles. Flat plates and streamlined sections have a tendency to stall at this angle. Perhaps the stall may not be sharp, but the effectiveness of the rudder is diminished.

We have detailed the many factors that determine the rudder area, and you will find over 2500 words on the subject in the other book. — When all was said and done, we found that it is perfectly safe to use the side view pattern for determining the rudder area of standard models. That is, if we use it correctly.

SIDE VIEW PATTERN

Contrary to what you may think, we cannot take a side view of a model, and pivot it a bit behind the C.G., to find the rudder area, without making certain changes. Perhaps the following illustration will help:

A pylon's center of lift in a 6° drift is around 30% of its Chord. To duplicate this aerodynamical force with side area, we must move the pylon forward, so that the center of the pylon's side area lies in the 30% aerodynamical point. See diagram. Now, we are duplicating, with side area, the aerodynamical force in true value. If we did not do this, the pylon's effect on the rudder area would be too low, resulting in an undersized rudder.

The same reason could be applied to any portion of the model. The fuselage, although it may have its center of force at 30%, can usually be used as it is because the C.G. of the model tends to be around this 30% point. But pontoons and any long object, should be checked for center of "lift".

The propeller has an effect. It can be simulated by using ½ of its frontal area as a side area in the pattern.

Dihedral presents an interesting problem. Since the wing also produces its "side" force at about 30%, we should move the wing area forward so that it will be equally divided about this 30% point as we did for the pylon. As a matter of fact, both items can be moved forward together. But what will determine the side view of the wing? We found that a side view of the left wing's dihedral will do the trick.

DIHEDRAL EFFECT IN SIDE SKID

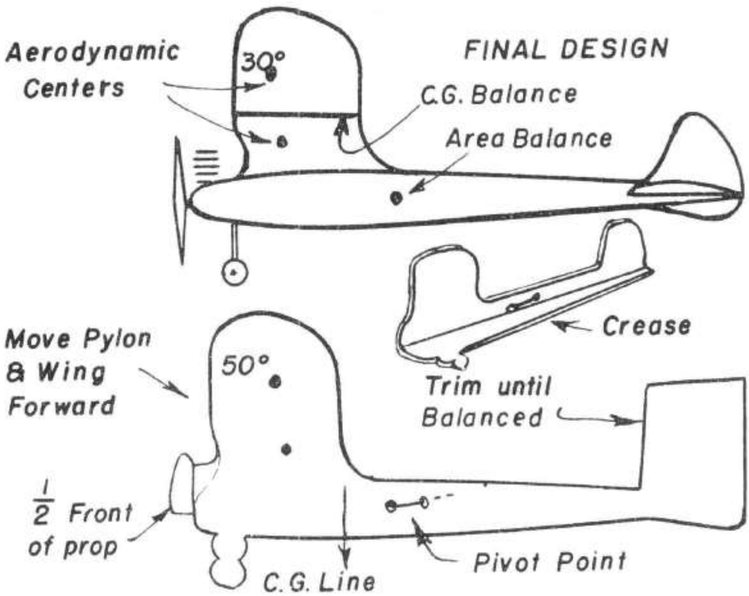
We have shown that the dihedral produces side forces, which tend to swing the model into higher drifts, unless checked by the rudder. — And so, the force value which is developed by the left wing, will be determined by the dihedral used on a given span. Therefore, a side view of the left dihedral will automatically determine the amount of rudder needed to balance it.

EFFECT OF THE C.G.

We have also shown that the effect of the dihedral will depend on the position of the C.G. If C.G. is at 30%, the side forces of the dihedral will have very little effect. This set-up in a side view pattern, would have the dihedral of the wing balanced about the C.G. so that no rudder area will be required, no matter how much dihedral you may have. Note how it all works out. But as soon as C.G. is moved back, the dihedral gets a moment arm. Duplicating this in side pattern, we see that a certain amount of rudder area will be required. Therefore, we can say that the location of the model's C.G. on the pattern should be carefully placed.

SIDE AREA BALANCED ABOUT C.G.

If we were to place the pivot point of the pattern on the model's C.G., we would obtain a balanced side area situation. This means that a slightest whimd would swing the model into or out of a side gust. To obtain necessary Direction Stability, the center of side area must be behind the C.G. Therefore, the pivot point of the pattern should be behind the C.G. But where to place this pivot, is now being asked.



PIVOT POINT ON PATTERN

Somehow we have a feeling that the span of the model should determine this spot. This will automatically, after a fashion, take into account the overall size of the model. After all, you cannot say 1" behind the C.G. and expect it to hold for models from 100 sq. in. up to 1000 sq. in. But a percentage of the span would do the trick as to the size of the model. So, let us say that the pivot point should be 4% to 5% of the span behind the C.G. Use lower value for large models, and higher value for smaller. Meaning that if span is 80", the pivot point should be 3.2". behind the C.G. For a 40" span, the pivot may be 2". This should take care of all sorts of things. But be ready to change rudder area if test flights indicate the step. Our present aim is to give you appropriate proportions.

PAPER PATTERN

Draw the above corrected pattern on an even texture paper. Leave rudder larger than expected, so that you can trim it to size. The pattern may be full size, but you will find that half scale may work better. If paper tends to curl, crease it as shown for rigidity. — It was a pleasure to make the side pattern method for finding rudder area into a science.

"V" STABILIZERS

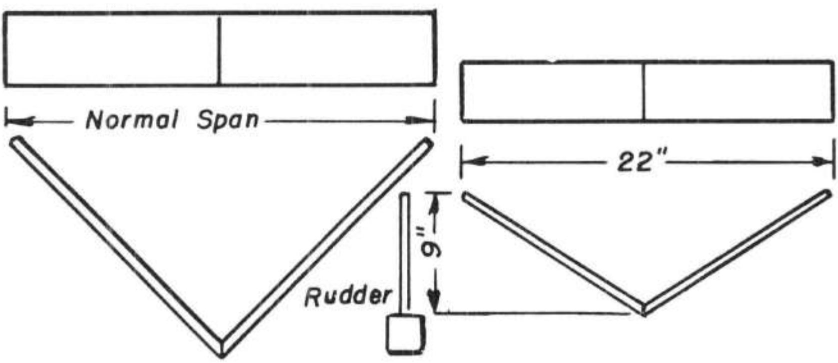
Calculating the "V" stabilizer can be quite tricky. After a few tries, we worked up a fairly simple system. It is based on the stabilizer area and C.G. position. Stabilizer area, as you know, is based on the position of the C.G. in relation to the position of the wing. And we have shown, that the rudder area is influenced by the position of the wing in relation to the C.G. It all ties up nicely, providing you have the correct stabilizer area for a particular design.

In all cases, the "look-down" span of the usual stabilizer will be preserved, regardless of the dihedral angle. Dihedral formula is as follows:

Stab Dihedral = 45° x C.G. location in % of Chord.

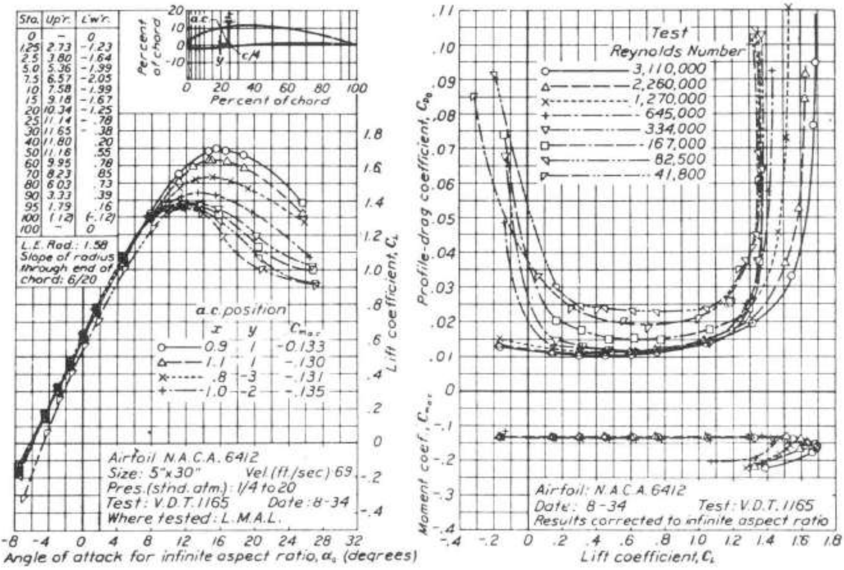
For example: If C.G. location is at 100%, the dihedral will be 45°. We checked this value and it works. In fact, you will find the procedure in the "other book." If the C.G. is at 35% spot, the dihedral will be 45° x 35% or 16°.

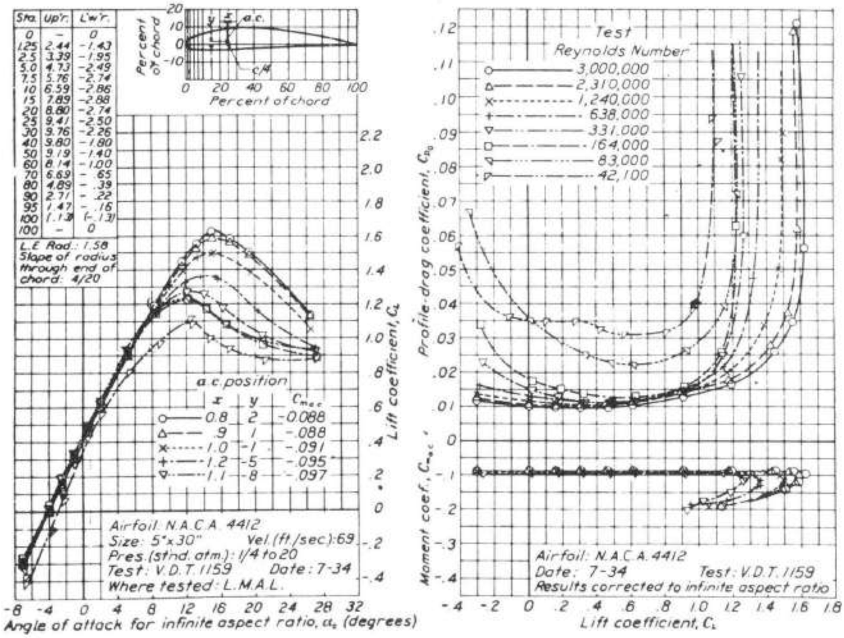
It seems to make sense. As the C.G. moves forward, there is less need for rudder area. It may not be the final answer, but it will help you decide on something for want of a better way. Before we forget, this formula should only be used when the moment arm is about 3 Chords long.—Increase dihedral by 1.5 for 2 chords, and by .75 for 4 chord moment arms.



Another method, which seems to check with our theoretical work, is first, to find the rudder area by the side pattern. Then taken this side view of the rudder, and use it as a side view of the dihedralled stabilizer. You have the "span" of the stabilizer fixed by the design. And the dihedral tip dimension will be determined by the rudder. For example; If span of stabilizer is 22" and has a chord of 4", a 35 sq. in. rudder would require about 9" under the stabilizer tip to produce the side area equal to rudder. See diagram.—

At least, you cannot say that we did not try.





AIRFOIL FORMULAS

The Lift and Drag formulas to be used with the airfoil charts shown are as follows:

Lift (In lbs.)—$C_L \times P/2 \times S \times V^2$

Drag (In lbs.)—$C_D \times P/2 \times S \times V^2$

C_L—Lift Coefficient C_D—Drag Coefficient

P —Density of Air (.00238 st 15° C. & 760 m.m.)

S —Area of Surface in Square Feet

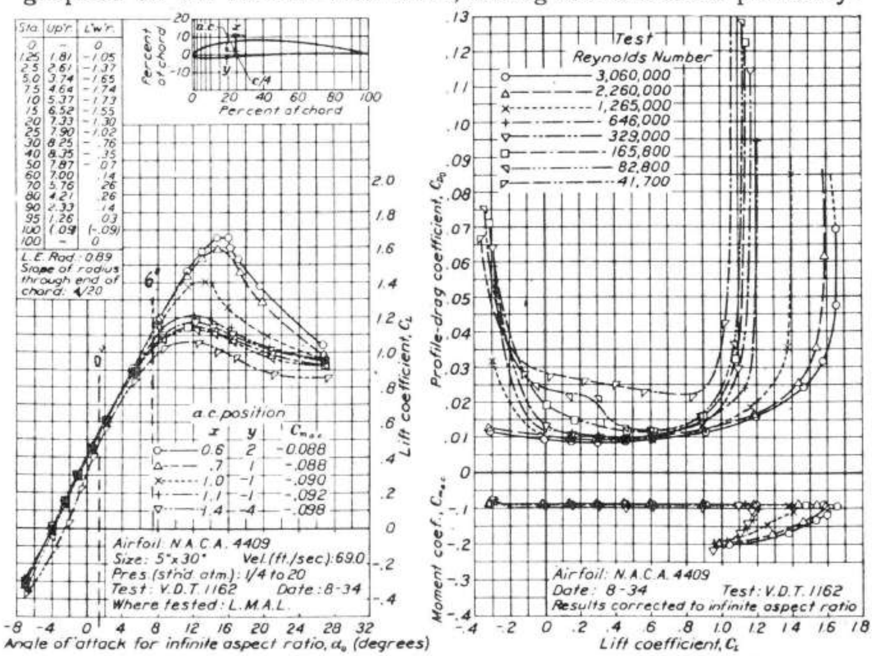
V —Air Speed in Feet per Second

AIRFOILS

All along the way we mentioned how the majority of the models stall at around 6°, some sooner, some later. Also, that under high power normally used on models, the model and its airfoil is automatically moved into lower angles of attack, so that it never gets close to a stall while under power. It is only when we try to obtain the maximum possible duration, through the slowest glide setting, that we come close to the stall of 6° or so.

Some of us may have been under the impression that the stall happens like that! (Snap fingers.) Actually, the process of stalling at low speed is slower. We could go into aerodynamical details and explain how the stall develops, but for our purpose we can obtain the necessary information from the NACA 4409 characteristics chart.

It just happens that our 200 sq. in. wing, having 5" chord and moving at 12.5 m.p.h., has a Reynolds Number of 41,700, and is graphed on the NACA 4409 chart, fitting our situation perfectly.



Note that up to 6°, the Lift Curve has a fairly steep slope, and that C_L at 6° is .9. — The Lift Curve from now on begins to move to horizontal position: And at 10°, it has reached its peak of lift. At 10° the C_L is 1.05. The Lift Curve from now on begins to slope down gradually. It does not drop down over the cliff. Just looking at the curve, one cannot see where the stall actually occurs. On the 3.060,000 Reynolds Number curve, we can definitely see a sharp peak, and say, "That is it!"

Now that you have had a good look at the Lift Curve, you might wonder why we kept on hammering at 6° stall. — Well, part of the explanation lies in the slope of the Lift Curve. Note that from 2° to 6° the C_L increased by.3. But from 6° to 10°, it increased only by .105. Meaning that for similar 4° increase of angle of attack, the gain in lift was only 1/3 as much. This means that from 6° to 10°, the efficiency of the airfoil drops down, but plenty. It should be obvious, that somewhere along the line, the lift producing qualities of the airfoil do not function so well. We might say, that the airfoil is in a stalling condition when lift gain per degree is low. And so, at 12.5 m.p.h. gliding speed, the NACA 4409 will begin to stall after it reaches 6° angleof attack. Note, we said, "It will begin to stall." Meaning that its lift will not drop sudden-like.

The second part of the story lies in the drag produced at 6° and at 10°. The Drag Coefficient at 6° is found over the .9 C_L. . This is .25. However, this is only the Profile Drag portion. We must include the Induced Drag Coefficient. We found it to be .03. Therefore, the total C_D is .055 for 6°.

For 10° the Drag Coefficient, we must look for it over the 1.05 C_L. Note that the drag curve moves off the chart. So, you can pick any value you like. We stopped at .10, to which we added .05 Induce Drag, for a C_D total of .15.

As you can see, it is the drag value that shoots up "like that!" when the airfoil moves from 6° to 10°. So, it is quite possible, that, as we try to obtain angles higher than 6°, the drag of the wing gradually begins to increase to a point where it slows up the model below 12.5 m.p.h. As the speed drops, the stalling angle may actually begin at 4° or 5°. To show the difference between the efficiency of the airfoil at 6° and 10°, the following characteristics are shown:

At 6°	Lift = 7.5 ozs.	Drag = .5 oz.	L/D = 17
At 10°	Lift = 8.0 ozs.	Drag = 1.25 oz.	L/D = 6.4

Note: The above discussion was based on the angle of attack given on the chart. In actual use, because of the "bump" under the 0 reference line, the NACA 4409 will be placed about 1½° higher than shown on chart. Meaning that what we considered as 0° setting, or incidence, will be 1½° on the chart. Therefore, for our personal reading, we should consider 0° and 6° on the lines shown. This moves our 6° stalling point closer to the chart and stall indication.

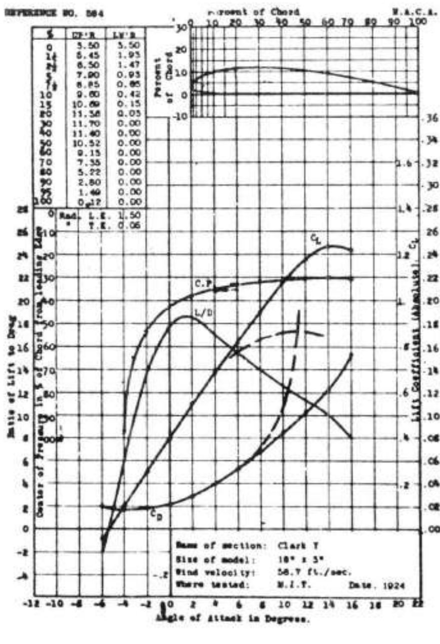
After we make the necessary correction for the 0° reference lines, NACA 6412 and 4412 also show signs of moving into stalling conditions after reaching 6°. The streamlined section, NACA 0009 also shows similar 6° characteristics. It, therefore, seems safe to assume, that at Reynolds Number of 42,000, practically all airfoils will tend to approach stalling conditions after reaching 6° angle of attack.

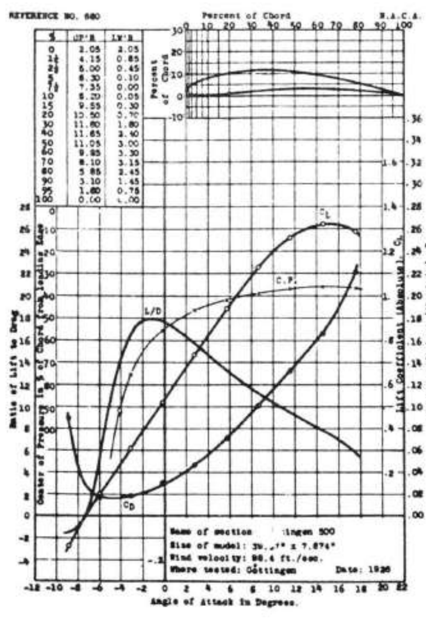
LOW SPEED AIRFOILS

The characteristic graphs shown for other airfoils are for higher Reynolds Number than we use. How to correct them for model work? We do not know how we can do it with a formula. But it may be possible to make approximate adjustments. Note that on the NACA charts, the lift values for all Reynolds Numbers seems to be on the same line. (The model's R.N. 42,000 is a bit off, but close enough). They remain together until they reach 6°. Now, the Reynolds Number begins to assign different directions. Our 42,000 R.N. line seems to break away at about 6°, and begin to curve, as shown, so that its peak is over 10°. We followed this assumption, and corrected Clark Y chart for model use as shown. Same procedure can be used for other airfoils.

We also wanted to find out the Drag Graph characteristics for low Reynolds Numbers so that we could change the regular charts. The graphs or curves are shown. We combined Profile and Induced Drag values to obtain the graphs shown. Here again the basic Drag curves are similar. Changes, however, occur near 0° and at 10°, as shown on Clark Y.

From what we have seen, it would seem that the average airfoil will act as usual up to 6°, and then change as per modification shown. It is safe to compare one airfoil against another in deciding which one to use, without worrying, "how it will behave at low speed."





WHAT AIRFOIL TO USE?

For duration models, the airfoil that will give most lift at 6° is the one you want. As you have seen it does not matter if the airfoil is undercambered or not, it will begin to approach stall and high drag after 6°. For gliders, the under cambered type seems natural. However, it will be up to your building skill. If in doubt about your ability to obtain true airfoil with your workmanship, use Clark Y type.

When we come to powered models, whose aim is also duration, we come to a peculiar situation. For glide we want a lot of lift. But under power, we want as little bit of lift as possible to obtain maximum climb. We know that the usual, and "automatic," procedure of the model to obtain low lift under power, is to swing into Circular Airflow angles. Here is where fun begins:

THIN AIRFOILS

Lately, the thin airfoils are being used to achieve smooth and fast climb. The light wing loading offsets whatever disadvantage the thin airfoil may have in glide. The usual answer to the question "WHY", is that the thin airfoil has less drag. It may be so, but, as usual, we have other ideas.

THIN AIRFOIL VS THICK AIRFOIL

There is nothing wrong in using thin airfoils when high lift is not needed. As a matter of fact, we always want the model to have a steady speed so that it will not be upset by slightest breeze. However, thin airfoils present structural troubles. If we can achieve same results, high and smooth climb, with a bit thicker section, it is a situation worth looking into. To clarify this point, we must make a comparison study between thin, or low lift airfoil, and thicker, or high lift type.

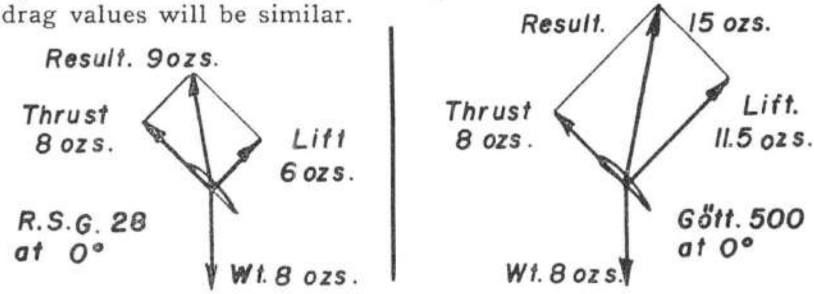
We looked a long time, but finally found two airfoils which represent fairly the two sides: Rhode St. Genese 28 and Göttingen 500. The characteristics are listed below. We are assuming 20 m.p.h. power speed. ***200 sq.in. wing.***

	6°	0°
R.S.G. 28	Lift = 16 ozs. Drag = .9 oz.	Lift = 6 ozs Drag = .27 ozs.
Gött. 500	Lift = 21 ozs. Drag = 1.56 ozs.	Lift = 11.5 ozs. Drag = .67 ozs.

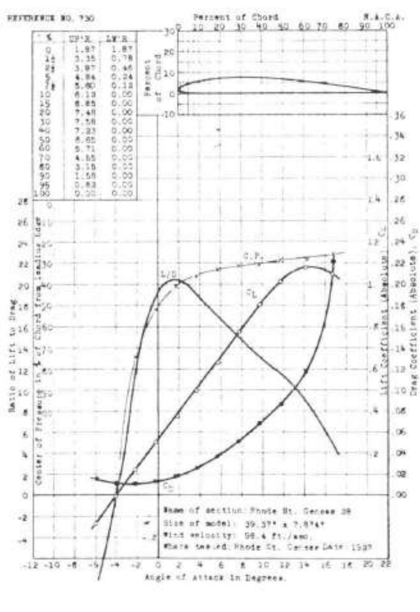
We should discount the 6° position under power, as we know that it does not exist right after we released the model. Our interest should be in the 0°.

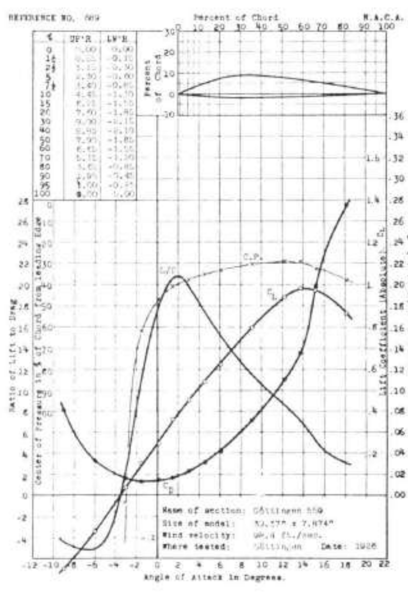
The difference in drag between the two airfoils is .4 oz. — Now, honestly, would you say that this accounts for the high and smooth power climb of the thin airfoil? Think, the motor has enough power to lift 8 oz. almost straight up. Would 5% of 8 oz. cause the big difference? The answer is not the difference in drag. It lies in the Lift produced by the two airfoils at 0°.

At 0°, the RSG 28 develops 6 oz. This is 2 oz. less than the weight of the model. We can see that this means no looping tendencies, and that the prop now also has a load. The Göttingen, 500, on the other hand, generates 11.5 ozs. of lift, much more than needed. You can expect that the model will still want to loop, or make tighter turns, to bring about the required Circular Airflow angles, so that its lift will be reduced to, say, 6 oz. — Checking the chart, the 500 will have to move to –3.5° before its lift will reduce to 6 oz. No way to do it but tighter turn or helix. Note that at –3.5°, the drag value is similar to RSG 28. Here again we see, that when we compared airfoils, lift for lift, the drag values will be similar.



Just to make things interesting, take a look at Göttingen 559. Compare its characteristics with RSG 28. Practically an overlap. But note the difference in thickness. On a 5″ chord, RSG 28 would be ⅜″ thick, while Gott. 559 would be 9/16″. You have 3/16″ more spar room. —



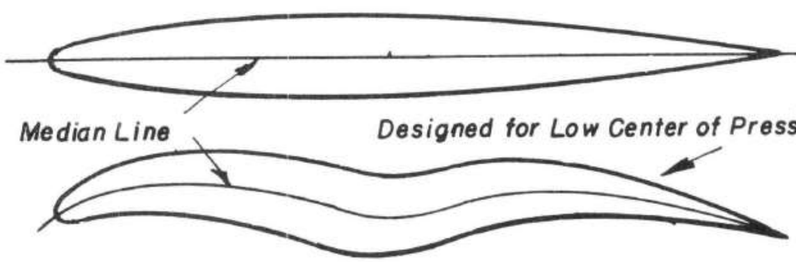


Going back to the original comparison, we can see that if the model is adjusted for the usual 6° glide trim, the Göttingen 500 airfoil would have to shift from 6° to –3.5° or a total of 9.5°, before it will produce the required 6 oz. While RSG 28 will only shift 6°. This means that the model using RSG 28 or any other airfoil having similar low lift characteristics at 0°, will be much easier to fly. It will safely climb in much larger helix. Larger circle or helix means avoidance of spiral stability troubles. So, for dependable and easier flying, it is advisable to use airfoils that have characteristics which we normally attribute to thin sections. Vis: low lift at 0°.

AIRFOILS FOR HIGH POWER, LOW WEIGHT MODELS

When wing loading is light, the airfoil may have low lift at 6°, and still compare in duration with heavier models using higher lift airfoils. The reason for using lower lift airfoil, as mentioned above, is to provide smoother and safer power flying. This means low lift at 0°.

The amount of lift that an airfoil will develop depends on shape of the median line. For example: On a streamlined section, this line is straight along the base line as shown. No lift at 0°. By cambering this line, we can obtain lift at 0°. The amount of lift will depend on the camber. RSG 28 and Göttingen 559 median lines have camber of about 3% of Chord; the Göttingen 500, on other hand, has almost 6%.



Once you have the median line, you can clothe it in almost any shape you like, as long as it is divided equally on top and bottom. You can take, within reason, thick or thin streamline shape and divide it around the line. Note the peculiar shape of Gött. 559, and its sharp contrast to RSG 28, yet the results are same as long as the median line is similar. The drag, may increase slightly as the thickness of the airfoil is increased, but the difference will not be as much as you may think.

It can, therefore, be said, that for high powered and light models, airfoils with low lift characteristics at 0° can be used for easier and smoother flying.

HIGH POWER AND HEAVY MODELS

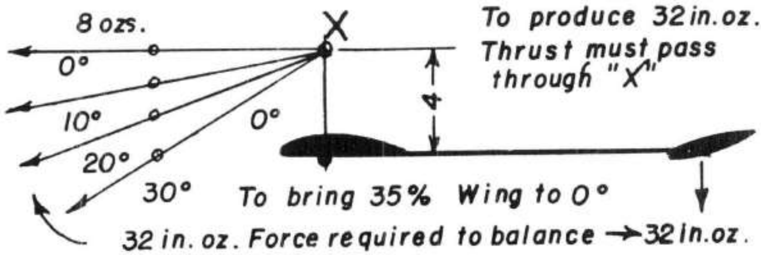
Here, we do not have much choice but use airfoils with higher cambered median lines. The problem is to bring about low lift under power without forcing the model into tight turning, or unstable 100% C.G. and 0–0 settings. The answer seems to be in using the slipstream blast on angled stabilizer, or downthrust, in combination with the usual Circular Airflow. Also longer moment arms will help. See design chapter. The actual choice of the airfoil will depend on your building ability. The deeply undercambered airfoils present construction problems. It might be well to use the top of such airfoils, but have flat bottom. Aerodynamically, such a change may mean less lift at 6° than indicated on the chart.

THRUST LINE

In our discussion of the Circular Airflow, we assumed that the Thrust Line was through the C.G., and always on the flight path; so that it had no influence on the outcome. — We showed how the wing's angle of attack was reduced by having the model fly in a circle or helical climb. Now, it is possible to bring the wing's angle of attack to lower angles by use of thrust line about the C.G.

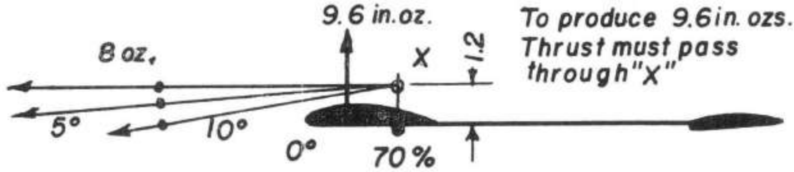
DOWNTHRUST OR THRUST LINE OVER THE C.G.

The basic purpose of Downthrust, in any form or shape, is to bring the wing down to lower angles of attack during power portion of the flight. By bringing the wing into lower angles of attack, the lift will be decreased to a usable value. By checking the Pitching Moment Charts, it is possible to obtain an idea how much Down Thrust Force is needed. If Thrust force is known we can actually calculate the need.



Although 35% C.G. models are just not being used, we can check it for Downthrust needs. Now, this is one design which we would not like to balance with Downthrust. We tried it, and ended up with 20° downthrust, while the engine was mounted 1″ above the C.G. All this on a 160 sq. in. model. The only way that this type of design can be balanced for high power, is to be prepared to give it 20° or more of downthrust.

A 70% C.G. model takes it more kindly. As a matter ot tact, an 8 oz. thrust force, passing 1.2″ above the C.G. would bring the wing to 0° without aid of Circular Airflow. — This would mean 6° downthrust on a rubber model on which prop is about 12″ from C.G. So that 3°, normally used, may be all that is needed. Especially when we realize that rubber motor may have more thrust than 8 ozs.

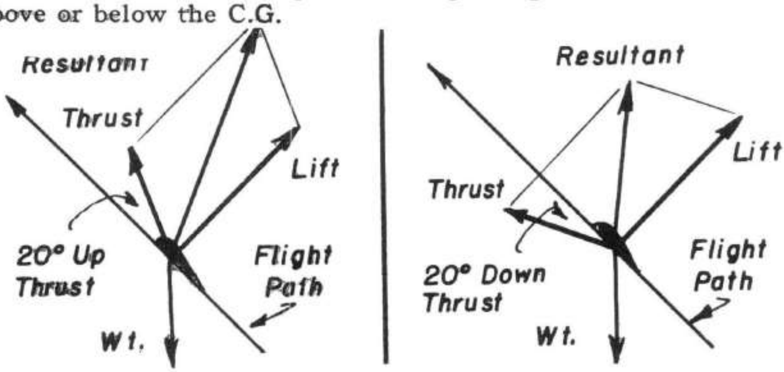


9.6 in.ozs. Force required to balance Wing's 9.6in.oz. in front of C.G. to bring Wing to 0°

The 100% C.G. does not need any help from the downthrust. The balance between wing and stabilizer is much too close at all angles. You can see this on the Pitching Moment Charts. As a matter of fact, we have shown that, if you have spiral dive troubles, and C.G. is close to 100%, you may try UPTHRUST; to help the wing control the stabilizer.

THRUST LINE AND FLIGHT PATH

The Thrust Line should also be considered in its relationship with the flight path. It is just a matter of triangulation of the thrust force. It can be seen that if the thrust line is angled above the flight path, a portion of this force will be used to nose the model upward. If it is angled downward, it will tend to nose the model down. However, this triangulation of forces has a rather mild reaction when compared with passing of the Thrust Line above or below the C.G.



An 8 ozs. thrust, set 20° down, will not have much effect on a 20 ozs. lift as shown. — But if this 20° line should pass 4″ above the C.G., it will bring the lift of the wing down to 10 ozs. Now, as shown, the conditions are in a better balance.

STABILIZER AREA

The stabilizer area is basically determined by the glide trim or balance. In such a glide balance, the wing is usually at 6° angle of attack. The area of the stabilizer, in such a trim attitude, will depend on the C.G. position, and the stabilizer's incidence angle.

As we wondered how we could devise an approximate formula to cover average needs, it came to us that if we could use C.G. position as a factor, a reasonable formula could be developed. If you recall, in the Pitching Moment chapter, we pointed out how the area had to be increased as the C.G. moved back. And so, the following:

STABILIZER AREA = Wing Area x .5 x C.G. Position in % of Chord.

As you can see, it assumes that at 100% C.G. spot, the stabilizer should be 50% of the wing. This is checked in practice, and it makes sense.

EXAMPLES:

200 sq. in. x .5 x 50% C.G. = 50 sq. in.
200 sq. in. x .5 x 70% C.G. = 75 sq. in.
400 sq. in. x .5 x 80% C.G. = 160 sq. in.

The above formula is for moment arms of 3 chords. Multiply results by 1.5 for 2 Chords, and by .75 for 4 Chords moment arms.

INCIDENCE DIFFERENCE BETWEEN WING AND STABILIZER

We also showed, in the Pitching Moment Chapter, that the angular difference, between wing and stabilizer, determines the longitudinal stability of the model: Greater angular difference means greater longitudinal stability. However, greater stability gives us looping trouble under high power.

The above formula will automatically give areas to fit the conditions required for model flying. And such conditions are determined by the position of the C.G. As C.G. moves backward, the stabilizer must have larger area. But, at the same time, it should develop lift, not only through the increase in area, but also by increasing its angle of attack. The formula seems to provide for all these things.

After the model is made, and C.G. is at the spot used in designing, the angular difference can be found by glide tests. Our examples should give you an approximate idea of the incidence difference.

Incidentally, if you have the wing and the stabilizer made, the size of the stabilizer will decide the C.G. position. Just make the C.G. position the unknown factor: $C.G. = \frac{\text{Stab Area}}{.5 \times \text{Wing Area}}$

GYROSCOPIC EFFECT

We found the most lucid and basic explanation of the Gyroscope, and its effect, in an article by Don Foote in April, 1950, issue of the Model Airplane News. A portion of this article, which deals with the basic facts, is reproduced herewith:

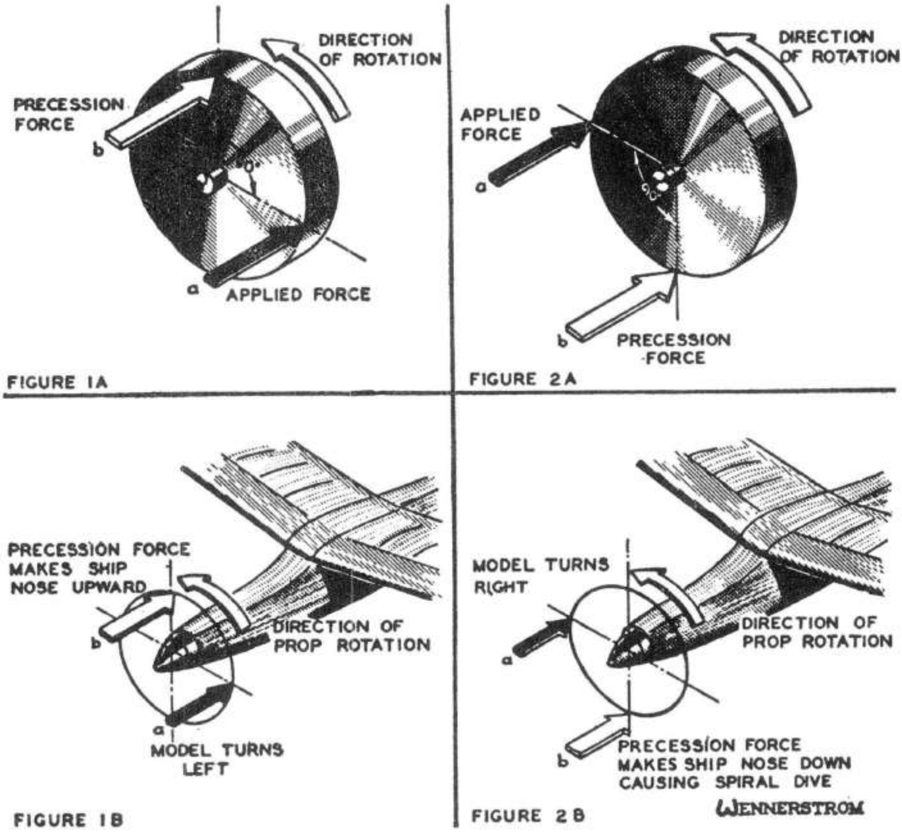


FIGURE 1A

FIGURE 2A

FIGURE 1B

FIGURE 2B

Fig. 1A shows a gyroscope turning in the direction indicated. When a force is applied at "a," causing rotation in that direction, then another force, 90° distant from that force in the direction of rotation of the gyroscope (at point "b") is set up which causes rotation in the direction indicated. This force is called "precession." Applying this to model aircraft, Fig. 1B shows a prop turning in the same direction as the gyroscope above. As it is turning fast and has considerable weight, it acts as a gyroscope. Now, if a force is applied at "a" (the airplane goes into a left turn), then a procession force appears at "b" which causes the rotation indicated. In other words, if the model goes into a left turn in the climb, a precession force will be set up that will tend to make the model nose upward. Hence, there will be a force acting to prevent spiral dives or "spining in" when the model is made to turn to the left in the climb.

Fig. 2A shows the precession force when the applied force is on the right side. Thus, when a model is made to turn to the right, a precession force is set up which tends to force the nose of the model downward and the airplane will spiral dive or "spin in."

The next step is to find out the exact value of this Gyroscopic Effect on a particular model, and see what effect it has on the model. Remember, we already have several possibilities which may cause spiral dives.

Our friend, D. J. Cameron, supplied us with a formula in the 1938 Year Book. And it is as follows:

$$\underset{(\text{in Lbs.})}{\text{GYRO EFFECT}} = \frac{.00043 \times W \times N \times V \times r^2}{X \times R}$$

W = Weight of prop (lbs.)
N = R.P.M. of prop
V = Speed of flight (M.P.H.)

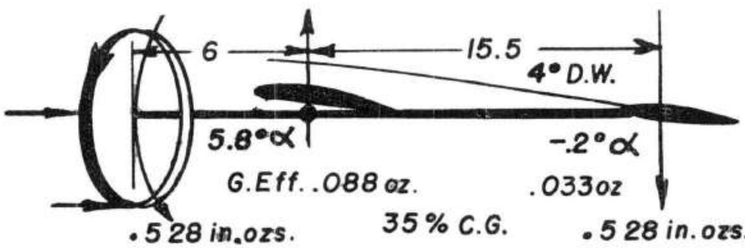
r = Radius of prop (ft.)
X = Distance of prop C.G. to C.G. of model
R = Radius of model's turn

For our example, we will assume 20 M.P.H., 8″ dia. prop which weighs .3 oz. R.P.M. 8,000. Distance from prop's C.G. to model's C.G.'s 6″. And circle diameter 100 feet. After making the necessary conversions, the problem is as shown in the formula (form):

$$\text{GY. EFF.} = \frac{.00043 \times .02 \times 8000 \times 20 \times .1}{.5 \times 50} = .0055 \text{ lbs.} (088 \text{ oz.})$$

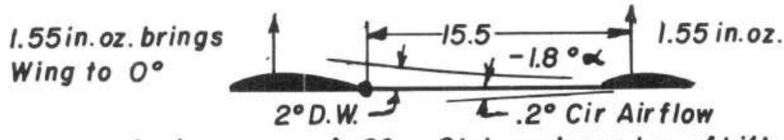
According to this formula, and the assumptions we made, the Gyro Effect is .088 oz. (If the circle had been 50 ft. in diameter, the value would have been .16 oz.) What effect will this force have on the flight?

According to the action of the Gyro, the above forces will tend to pull the front of the model down by the value shown if the model's circling to the right. Here is where our Pitching Moments come again in to the picture. — .088 oz. force on a 6″ moment arm would be .528 in. ozs. To counter this on its 15.5 moment arm, the stabilizer would require .033 oz. of lift.

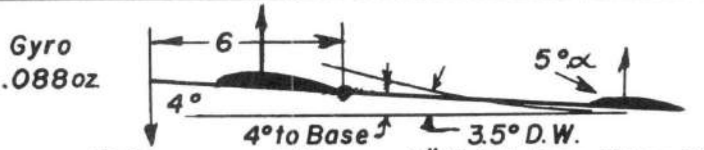


The question now is: What effect will this .033 ozs. load on the stabilizer have on the flight? On the 35% C.G. model, it will make practically none. It would bring the stabilizer from its "normal" 0° to –1/5°. — On the 70% C.G. model, the result would be the same, a decrease of 1/5°. (Meaning that stabilizer may lift less for balance).

The 100% C.G. is the closest to being in trouble. We found that to bring the wing to 0° angle, the stabilizer needs no more than .2° increase. In shape of actual force, it is .1 oz. Now, force of the Gyro Effect is.5 28 in. ozs. To find out how much it will effect the stabilizer, we divide this value,.5 28, by stabilizer's moment arm of 15.5". The answer will be .033 oz. It is possible that this .088 Gyro Force will bring the angle of attack from 6° to 4°. — Here is the possibility of that spiral dive.

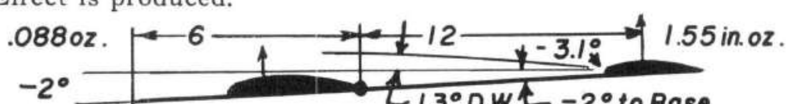


An increase of .2° on Stab produces .1 oz. of Lift



.088 oz. on 6" M.A. brings Wing 4°

If the 100% model already had that .2° stabilizer increase, due to the Circular Airflow, the wing would be at 0°. Now, adding to this, we have Gyro Force of .088 ozs. which tends to decrease the wing's angle of attack by another 2°. This means that the wing is now flying at –2°. —

In conclusion, we can say that the Gyro Effect might tip the scale on a delicately balanced model. By itself, it does not seem to have enough power. For example, if the model was flying in a circle with the wing level, it would have no angular reduction due to Circular Airflow. And the Gyro Force alone would not be strong enough to upset it. In fact, it might supply just the right amount of angle of attack reduction. As a matter of fact, the 100% model should not fly in circles small enough in which Gyro Effect is produced.

Combination of .2° on Stab & .088 oz. Gyro brings Wing from 6° to –2°

Here again we see how a model, having 0-0 setting and C.G. at 100% can be made spirally unstable by a very minute force. — But on models that have C.G. closer to the 50%, the Gyro Effect can be forgotten. That is, until someone gives us factors that will make the present formula incorrect. — Until then, consider this as an academic study. Or how we would do it, if we had the correct data.

DESIGNING GLIDERS

It is relatively easy to make a glider. If you are satisfied with large roaming circles, most any kind of layout would do. You can use small or large stabilizer. A bit of tip dihedral and small rudder. Or plenty of rudder and dihedral. As long as you have no particular wish to make tight circles, you can make anything you like. But comes a bit of wind, you better put your "anything" away. As soon as the air becomes disturbed, you need a design that seems to have a life of its own.

DESIGNING TIGHT CIRCLING GLIDER

Safe tight circles are especially important in windy or gusty weather. The behavior, of a well designed, tight circling glider is a wonderful sight to behold in high and gusty wind. Somehow, the glider always manages to swing into the wind, and use its downwind inertia to gain few feet. It does not tarry long, fighting the headwind, but quickly raises its outside wing and sweeps downwind, only to repeat the cycle by swinging into the wind. At no time does it rest. Always bouncing around. Sometimes we wonder how it manages to accumulate as much time as it does. — It should be evident that such a glider must be exceptionally stable, and have very powerful turn adjustments.

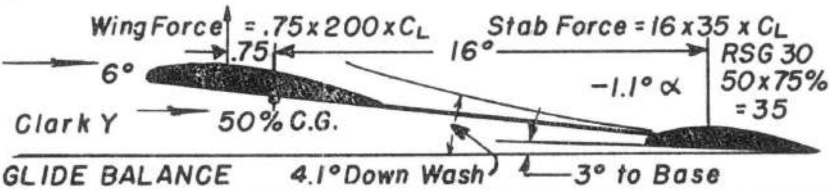
For thermal flying, we also need a tight circle, otherwise many small thermals will be passed through. And when the glider does hit a "lulu", it must be able to withstand an increase of speed. Check the thermal rise, and forward speed of the glider. You will note the resulting airflow tends to make the glider speed-up. And an increase in speed means tighter circles. Therefore, the model must have plus and minus leeway, so that the Circular Airflow angles, produced in tighter circles, will not make the wing lose lift too fast. Just make a couple of Circular Airflow calculations and you will see what we mean.

ADJUSTING FOR TIGHT TURNS

When we began to specialize in gliders, our basic turn adjustment was to remove weight from the nose, as we tightened the circle with the rudder. If we used rudder alone, the glider would tend to spiral dive. At that time, we had no special reason for using this particular system; just found it by process of elimination. We had an idea that the wing, when banked, lost some of its lift due to triangulation of its main lift force, and that by taking weight out, we would balance this loss. We never stopped to think, that a removal of only 1/10 oz., on an 8 oz. model, would bring it from a spiral dive, into a floating glide; or that the banked position was the same for the wing and the stabilizer, so that their longitudinal balance should have been preserved.

After finding the Circular Airflow theory, the above procedure made sense. See the following Pitching Moment Charts.

The requirements for tight circle, point at 35% C.G. designs. From experience, we found that 50% C.G. position is a good compromise. The Chart shown, uses our usual 200 sq. in. wing. Although we used 50 sq. in. stabilizer, according to the formula, we assumed it to be 70% efficient; due to loss of area where it rests on the fuselage, and other interference. Also, we used Rhodes St. Genese 30 to follow the practice of using thinner stabilizer. The calculations are straight forward. The balance point occurs, as usual, at 6°.



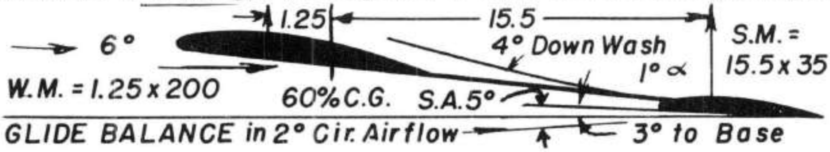
W.A.	W. C_L x W.M. = W.F.	D.W.	S.A.	A.S.A.	S. C_L x S.M. = S.F.	
2°	.54 x 150 = 82	2.7°	−1°	−3.7°	.025 x 560 = 14	Wing
3°	.62 x 150 = 93	3.1°	0	−3.1°	.075 x 560 = 44	
4°	.7 x 150 = 105	3.5°	1°	−2.5°	.12 x 560 = 67	
5°	.76 x 150 = 115	3.8°	2°	−1.8°	.16 x 560 = 90	
6° A	.82 x 150 = 123	4.1°	3°	−1.1°	.22 x 560 = 123	Bal.
7°	.88 x 150 = 132	4.4°	4°	−.4°	.27 x 560 = 150	Stab
8°	.95 x 150 = 140	4.8°	5°	−.2° B	.31 x 560 = 175	

The above conditions will exist when the glider is flying straight ahead, or in large circles without having the wing banked. Then we decide to make it turn tighter, say, 35 ft. As we go about in obtaining this circle, by removing weight and setting rudder, we find that the C.G. gradually moves back. By the time we obtain the 35 ft. circle, we find that it is at 60%, also, that the bank of the glider is now 40°. Just why did we have to remove weight?

Checking the Circular Airflow for the change that took place, when we adjust for 35 ft. circle and 40° bank, we find that the angle of attack on the stabilizer has been increased by 2°. If we had not removed weight, the increase of 2° on stabilizer would be like saying that the wing would be flying on line "A", and the stabilizer on line beyond "B". Note the Unit values, and how much more power the stabilizer has under such condition. As a matter of fact, if we had not removed weight, the wing would be forced to 2° before it would balance the stabilizer at its −1.8° angle of attack.

By removing weight, we gave the wing an additional moment arm of ½". The wing can now balance the extra force of the stabilizer, due to its increase of 2° angle of attack. We made a Pitching Moment chart of the new situation.

It should be evident, that if you try to fly this new 60° C.G. Circling arrangement in a straight line, stalling will result. The stablizer will not get the required 2° increase in a straight flight.

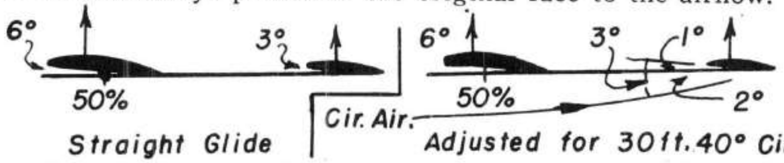


W.A.	$W.C_L$ x W.M. = W.F.	D.W.	S.A.	A.S.A.	$S.C_L$ x S.M. = S.F.	
4°	..7 x 250 = 175	3.5°	−3°	−.5°	.21 x 543 = 140	↓
5°	.76 x 250 = 190	3.8°	4°	.2°	.31 x 543 = 170	↓
6°	.82 x 250 = 205	4.1°	5°	.9°	.37 x 543 = 201	Bal.
7°	.88 x 250 = 220	4.4°	6°	1.6°	.42 x 543 = 225	↑

NEW ADJUSTING METHOD FOR TIGHT TURNS

Since we now know what is happening, we developed a new method for adjusting gliders: Take any glider you may have, set wing and stabilizer so that the model will glide well straight ahead with C.G. at 50%. Add or remove weight to find this position. — From now on you leave weight alone. You will balance rudder setting with the stabilizer. To adjust for turning, gradually apply rudder. Glider will naturally steepen the glide. Correct this by setting stabilizer enough negative to obtain a smooth floating circle. Tighten up with rudder again. And correct for smooth flight with the stabilizer. —

If you had followed the above procedure on our 50% C.G. model, you will find that by the time you got to 35 ft. and 40°, the decrease on the stabilizer would be 2°. Meaning, that you may have started with the wing at 6° and the stabilizer at 3°, but you ended up with wing at 6° and the stabilizer at 1°. — All we did was to anticipate the Circular Airflow, and moved the stabilizer so that it always presented the original face to the airflow.



Some of you may have noticed that our personal designs have at least 6° difference between the wing and the stabilizer. Originally, we did this to keep fuselage in flight path, but now we see that it also helped in developing tight turns. — Such designs, 6° wing and 0° stabilizer, are not designed for straight flight, but for tight circling. Anyone who has seen a "Floater" or "Thermic 72" operate, will know what we mean. Also, on such models the original adjusting procedure should be used, removing weight as turn is tightened with the rudder. Because, on a straight flight you had to add weight to bring C.G. ahead of 50%. Whatever you do, end up with 50% C.G. position while model is giving you the circles you want.

WHY 50% C.G. POSITION IN GLIDE

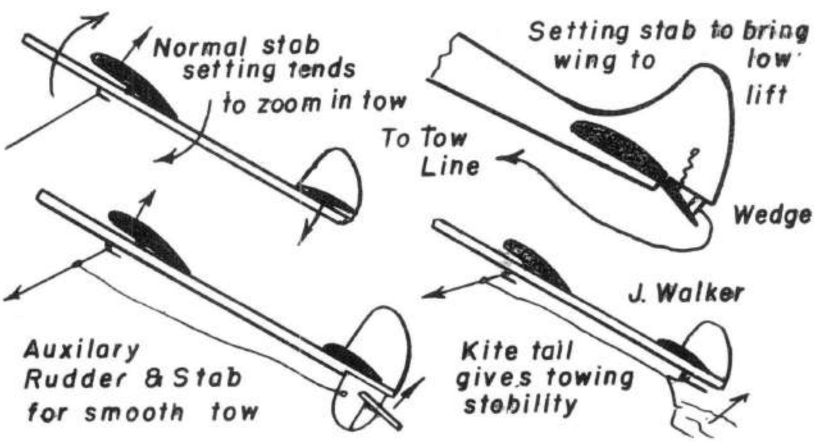
The reason we want to keep C.G. at 50% during circling, is to keep the original relationship between the wing and the stabilizer. If you will check the 50% C.G. Pitching Moment chart, you will notice that the force values change fast to plus or minus around the 6° balance. This means that any gusts or changes will be quickly adjusted. But if you move C.G. backward, as you do when you adjust by removing weight, the force values become smaller. Note the difference in values between the 50% and 60%. — If you should use a larger stabilizer, and adjust so that the C.G. is at 80% in a circle, the model will no longer posses that bouncing characteristic so desired in thermal hunting gliders.

TOWING

Towing a glider, that has a large turn set, is no problem. You can get them up overhead without fuss. But it is a different story with the tight circle thermal hunter. —

TROUBLE WITH ZOOMING

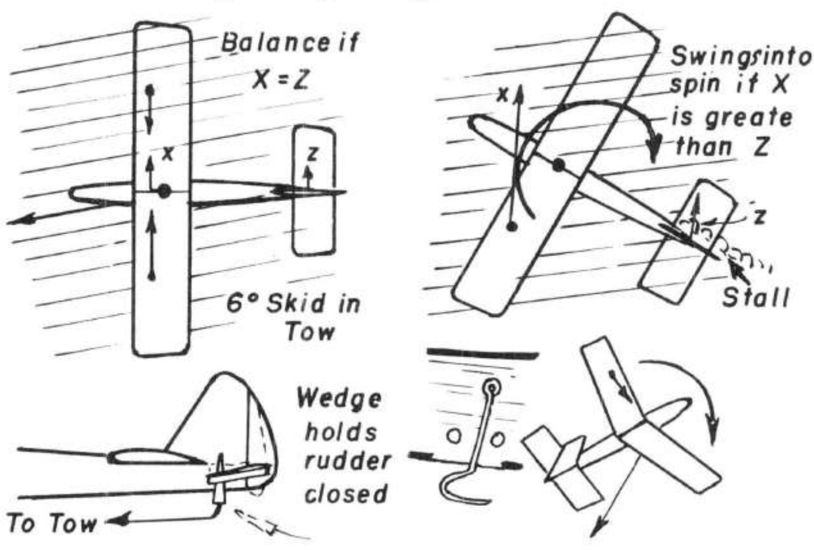
As we have shown, when we adjust for tight turn, we give the stabilizer negative as we tighten the circle. If we were to try for a straight flight with this stabilizer setting, we would have stalling results. Now, in a tow, we have a straight flight forced upon it. So, it is only naturally for the glider to attempt looping. Somehow, we must correct this. Since it was caused by negative stabilizer, we would have a smooth straight tow, if we could remove this negative incidence during the tow. It may be possible to do this with an adjustable elevator by using a wedge, which comes off with the tow line. — Or we may use a sliding weight. This weight would be back for normal 50% C.G. turn, and forward during tow. It could be on a dropable stick. Or we would carry an auxiliary stabilizer in combination with rudder "golf stick."



TROUBLE WITH SPIRALS

A rudder set for tight turn will also give trouble during tow. It should be neutralized. Either with an auxiliary rudder, or wedged tab which is freed by tow line when it is released. How does rudder give trouble? — It is the rudder setting, in combination with the dihedral, that does the dirty work.

Assuming that the rudder is set for a right turn, the model will tend to move into skid angle as shown. In such a skid angle, the left wing will tend to lift more than the right. All would be well, if this is as far as the model moves, and if the rudder area is large enough to prevent the wing from trying to swing into still greater side drift angles. If the rudder is too small, the dihedral side force effect in front of C.G., will produce the familiar wing over, and a spiral dive; with you holding the string, wondering what to do. — Stop wondering, drop it or run towards the glider, and let the line slacken. Tightening will only give the left wing greater force. Check up on Test #11, and you will know what is happening. Therefore, it is very important to neutralize the rudder setting during towing.

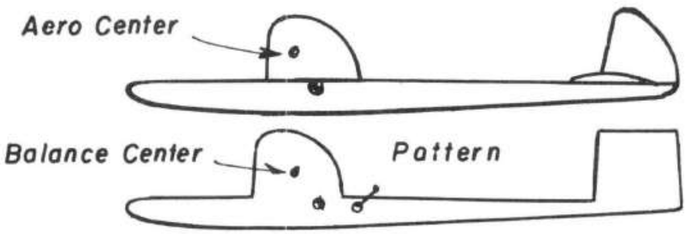


TOW HOOK POSITION

Have a couple of them, and find the best position by tests. — Hooks should be on the center. Side hooks may work in offsetting rudder adjustment, but neutralizing the setting is the best way. And with a wedge, it should be no problem. We are wondering what would happen if we had it pivoted as high as possible, so that it will not swing the model into high angles of attack at the beginning. Also, it is possible to make such a hook stop to fit conditions.

SUMMARY

We may not have given you any specific design layout, but you can find all you need from the preceding chapter. The only factor you may miss is the dihedral angle. 1½" under tip for every foot of span is plenty. You can break it up into tip, or polydihedral. Once you have the dihedral, you can check for rudder area with side pattern. The C.G. position should be at 50%. Since wing is effective at 35%, be sure to move its dihedral side area *15%* of chord ahead of the C.G. — See sketch.



HAND LAUNCHED GLIDERS

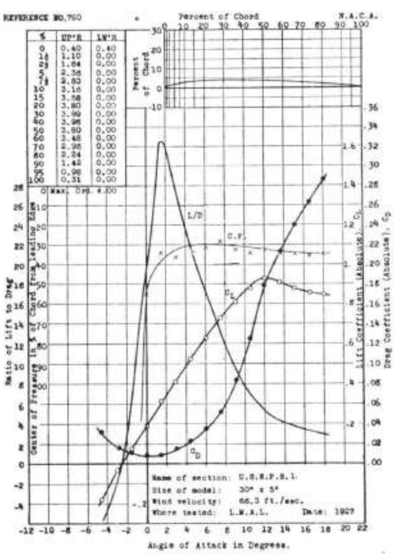
The present day hand launched glider is a creature of evolution. Its design is exactly according to the theory. Yet, no one knew why the design had to be as it is, while trying to get most height with a given moment arm power. With the aid of the Circular Airflow Theory, the action of the present day hand launched glider can be explained.

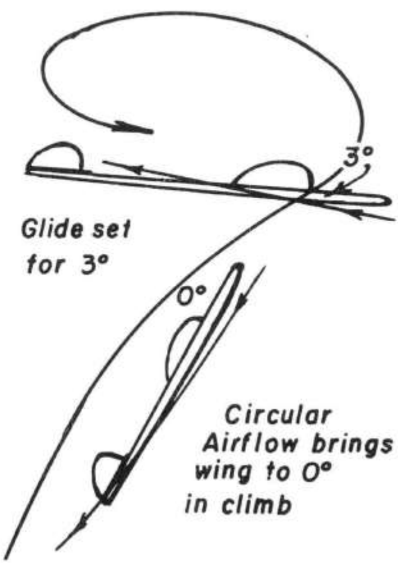
The design is definitely 0-0 layout, with C.G. between 50% to 60%, and further back in some case. It is a known fact, that such gliders have very touchy longitudinal stability, just a slight addition of weight would produce dive tendencies. In other words, we have Pitching Moment conditions similar to our 100% C.G. and 0-0 layout. And as we know, such layout is good for high power or high speed. (Also see Effect of Thin Airfoils in Circular Airflow.)

The problem with hand launched gliders is to get them up as high as possible. By using 0-0 and C.G. far back, it is possible to obtain practically zero lift conditions with very slight change in the angular set-up. We can get this slight change through Circular Airflow. By launching the glider in a steep, one spiral turn. the Circular Airflow angle produced will give the stabilizer angle slight positive. This will bring the wing to low lift condition, and so prevent looping, and also present minimum drag "face". No matter how you do it, you will find that the glider will have a slight curving path at all times, while it is on the way up. Closer the C.G. is to the trailing edge, so much easier it will be to get the model up without too much trouble. But it is another story after recovery.

It is very difficult to obtain small circles with 0-0 design having C.G. far back: Especially when using minimum of stabilizer area. Just a slight change in the angular difference between wing and stabilizer will produce spiral dive as per book, or a stall. Such a glider has a definite minimum circle, which may be too large for most of us. Any change to make it fly tighter, and still have good launching characteristics, will develop spiral dive. This is natural, because as circle is decreased, the Circular Airflow angle increases. And you know what happens to the stabilizer in such a case. — The only way to obtain safe tight turns is to have the model skid around without banking. How to do this, we cannot say. Perhaps, smaller dihedral and rudder might help.

In designing gliders for beginners, consider the trouble one can have with 0-0 designs, and how easily they can be made to spiral dive. So, incorporate a bit of negative stabilizer, and be sure to stress the position of the C.G. Also, stress the side arm launch technic with opposite adjustments. That is, left turn adjument for right turn launch.





AIRFOIL FOR H. L. GLIDERS

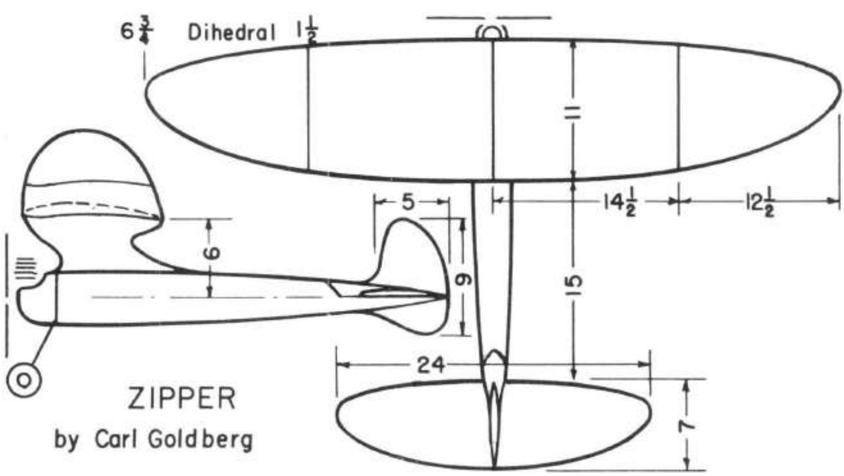
We found this airfoil in one of our treasured N.A.C.A. books. It will give you an idea of thin glider airfoil characteristics. Note its low lift at 0° which makes it good for Circular Airflow control of climb. Or, rather, it shows why thin airfoils can be made to have smoother power climb. If chord is 3″, the thickness is 1/8.

EXPLAINING THE OLD GAS MODELS

Since the "Zipper" could be called the beginning of it all, controlling high power on small models, let us examine its characteristics in light of what we think we know now.

Our memory of it is still vivid enough for us to remember that it "was" or "wasn't." If it did not have just the right spiral climb, it would loop or spiral dive. If motor cut in time, it would settle into a meandering glide. — Perhaps, its outstanding value was that it did not matter how it was made, it would fly somehow. That is, the builder did not have to worry about turn adjusments. He had them, or did not! This is not meant to slight the design, rather it is meant to show that a beginner had a chance to obtain flights without adjusting.

Now that we have this thing called Circular Airflow, we can explain Zipper's actions. In a glide, the model did not seem to lack rudder area. It would wander around, and on occasion change its direction. Yet, under power it would develop a definite right spiral climb or dive. To us, this means that the torque caused the usual side slip so that the dihedral could bring it under control. "Zipper" was one of the first models to use generous dihedral. (Basset had it, if we knew then how important dihedral was, we would not have been so miserly in worrying about lift lost due to dihedral.) It also had C.G. further back than other models of that time. In all, we had the set-up which we showed in Test #11; the development of side forces by the Left Wing in front of the C.G. The generous pylon may have just balanced the side area pattern, as we know it, but the rudder area definitely did not take into account the extra force developed by the dihedral during power. The result was that the model had built-in right turn under power.



ZIPPER
by Carl Goldberg

Its longitudinal stability was fine during glide. This meant that the C.G. was not at 100% point, and that it had longitudinal dihedral, meaning angular difference between wing and stabilizer. This arrangement called for a considerable amount of Circular Airflow, before the model reached the position in which the wing had 0° angle of attack; or less, because of its high lift section.

So, we can say that the action of the "Zipper" was almost automatic. Having large dihedral and small rudder, it had a natural tendency to turn to the right under power. And in the turn, it developed the required Circular Airflow to reduce high lift. If it had more rudder, it might not have been able to develop the turn, and the only possible way it could go, would be to loop.— On occasion, when the model was poorly made or warped, the delicate balance under power was upset, and spiral dive was the result. Or it would happen when the motor developed more torque than the design could handle.

That above has semblance to true facts, can be judged by the fact that when lower power was used, it became a very docile machine.

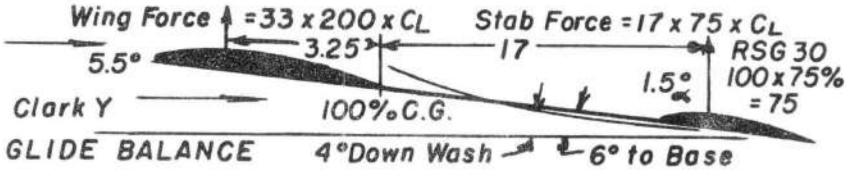
DESIGNING GAS MODELS

The design of gas model has been pretty well covered in the general text. We showed the effect of torque on dihedral, and have given enough examples so that you can work out your own problems. If you know the torque of your motor, you can actually design the entire model. You can guess at its speed. Estimate the R.P.M., prop used and its slip. Once you have the speed, you can find out how much the wing will lift. Do not be afraid of using regular formulas. They will come much closer than your guestimating. After you know the lift, you can estimate the dihedral needed for control. You can take our approximations if you like. After you have the dihedral, the rudder area will depend on the layout.

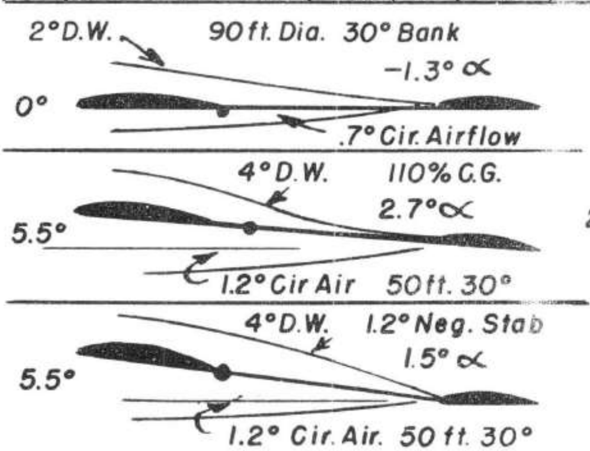
PITCHING MOMENTS

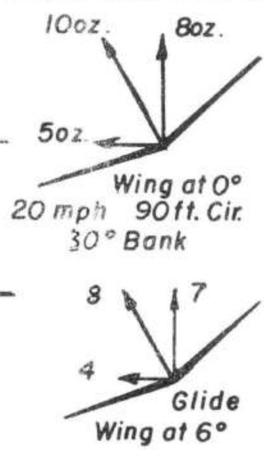
You might wonder where to have your C.G. This will depend on your power loading. If you have a lot of power, and a small model, you should use 100% C.G. This will make power flying easier. We laid out a 100% C.G. Pitching Moment, using R.S.G. 30 for stabilizer. Looks good. It has a bit more longitudinal stability than Clark Y. In a sense, it is equivalent of having Clark Y at lower angle.—

When flying a model, having the above Pitching Movement characteristic, you should be careful about its circle. Theoretically if its speed is 20 m.p.h., it can fly in a 90 ft. circle, with a wing banked 30°, and still produce enough vertical lift. Tighter circles may mean spiral dives.— (In a 90 ft. circle, a 30° banked model will develop .7° Circular Airflow, which brings the wing to 0°.) As for gliding turns, if you can keep the wing flat, you will be all right. We made some calculations. If the surfaces were left at 0-0 setting, the C.G. would have to be moved to 110% point if you wanted a 50 ft. circle and 30° bank. Or we might say that, if you could give the stabilizer 1.2° negative during glide, you could leave the C.G. alone, and still get the 30° and 50 ft. circle. Or you might fly with a bit of downthrust. This would mean that the C.G. could be at 110% or Stabilizer at -1.2°. The upward tendency of the wing would be cancelled by downthrust. All moves, of course, should be done with discretion and delicacy. The main fact we want to show, is the reasons why 0-0 setting and 100% C.G. models are so touchy. If you know the cause, you might find the solution.



W.A.	W.C_L x W.M.=W.F.	D.W.	S.A.	A.S.A.	S.C_L x S.M= S.F.	
-2°	.25 x 650=160	1.2°	-2°	-3.2°	.06 x 1275= 76	Wing
-1°	.33 x 650= 220	1.6°	-1°	-2.6°	.11 x 1275= 140	
0	.4 x 650=260	2°	0	-2°	.15 x 1275= 191	
1°	.47 x 650=310	2.3°	1°	-1.3°	.2 x 1275= 255	
2°	.54 x 650= 350	2.7°	2°	-.7°	.25 x 1275= 320	
3°	.62 x 650= 403	3.1°	3°	0	.3 x 1275= 382	
4°	.7 x 650= 433	3.5°	4°	.5°	.345 x 1275= 440	
5°	.76 x 650= 494	3.8°	5°	1.2°	.38 x 1275=485	Bal.
6°	.82 x 650 = 533	4.1°	6°	1.9°	.43 x 1275= 548	Stab.
7°	.88 x 650= 572	4.4°	7°	2.6°	.47 x 1275= 599	
8°	.95 x 650= 627	4.8°	8°	3.2°	.51 x 1275= 663	



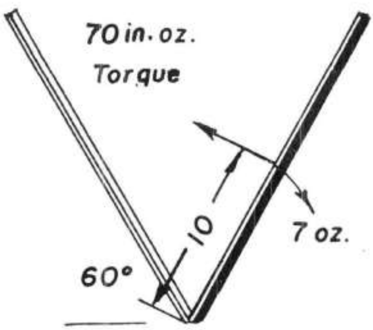


DESIGNING RUBBER POWERED MODELS

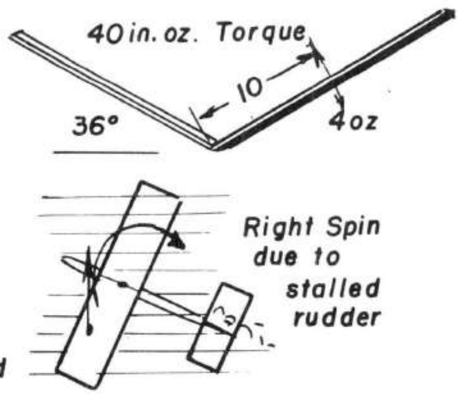
We knew how to control torque with dihedral way back in 1938, but for some reason or other, we assumed that the drift angle could be of limitless value. We knew that drift angles were required, but it did not occur to us that the drift angles must be kept at 6° or below. In the 1938 Year Book, we have a classical example: To control 40 in. ozs. torque on a 12° dihedral wing, having 40″ span, we called for 30° Drift. It makes us wonder about our readers. No one brought this fact to our attention.

HIGH TORQUE AND SMALL WING

In the Dihedral section, we showed how to find drift angles for a given dihedral and torque, or how to determine dihedral if torque and maximum drift angles are known. We estimated that 70 in. ozs. torque, developed by a 16 strand; ¼ Dunlop Rubber, needs 60° dihedral. (We can take heed from these facts.) — And that a 40 in. ozs. torque would require 36° dihedral. This means 6″ under each tip for every foot of span. Rather more than we had been accustomed to use.



To develop 7oz. in 6° Skid



The symptom of insufficient dihedral is the tendency of the model to spiral to the right while under power. Reason: The given dihedral, being too small, has to develop higher side slip angles than 6° to control high torque. As the model passes this safe 6° value, the rudder begins to stall and lose control of the situation. Once it loses control, the frontal portion of the model has greater power about the C.G., and throws the model into right spiral. — Once the model begins to develop a turn, it comes under the influence of the Circular Airflow. If the turn is small, the Angular Change will be great, and the model will lose over-all lift. Although dihedral may not actually do the work, it starts the process of spiral dive. — If you have been to a Wakefield meet or other rubber powered contest, the right spiral at the take-off is the usual hard-luck occurence.

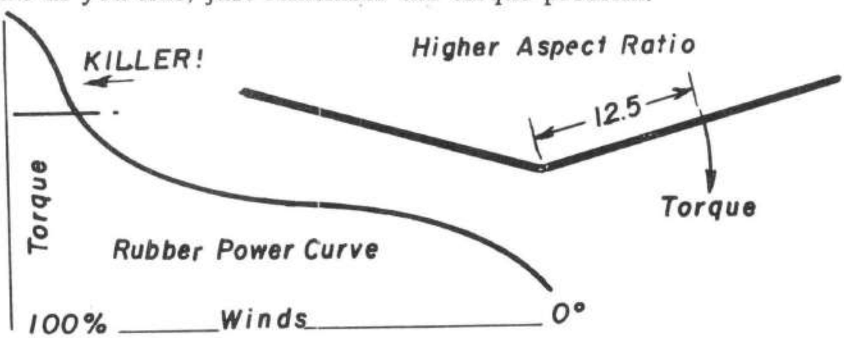
In 1949, we made a comment in one of the magazines, that it was quite possible, that Ellila won the 1949 Wakefield because he did not wind his motor to its maximum possibilities. At that time many of us felt that Ellila could have done better if he had wound to the last turn.

Remembering now the way his model behaved, makes us think that he did not have the usual torque trouble. The model just had enough power to keep boring into the wind and maintain flying speed. In the meanwhile, the other boys tried to get that last bit of power. The result was exceptionally high torque, which was beyond the power of the model to control. — Not knowing many of the things we know now, we did not go further into lower torque possibilities. But since we began to study the subject in detail, we wonder what sort of a design will win in the future.

LOWER TORQUE NEEDED

Somehow for safety's sake, we have to keep torque to values below 40 in. ozs. We can do this by unwinding few turns from the peak. — It also means that we may gradually get away from high power climb and hope for a better glide. As a matter of fact, we seem to be heading into that direction, whether we like it or not. Wakefield rule has 5 min. as maximum. And our own rules now have 6 min. maximum for rubber models.

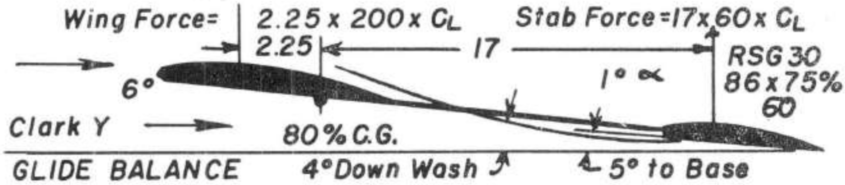
With Wakefield rules allowing unlimited fuselage length, it is possible to have longer motor of fewer strands than now used. It will be a matter of designing props to fit. — The return gear system has lots of possibilities. We used it back in 1934, and had guaranteed motor run of 3 min. But we wonder how many have the temperament to handle two motors. It is trying on a hot day. Do as you like, just remember the torque problem.



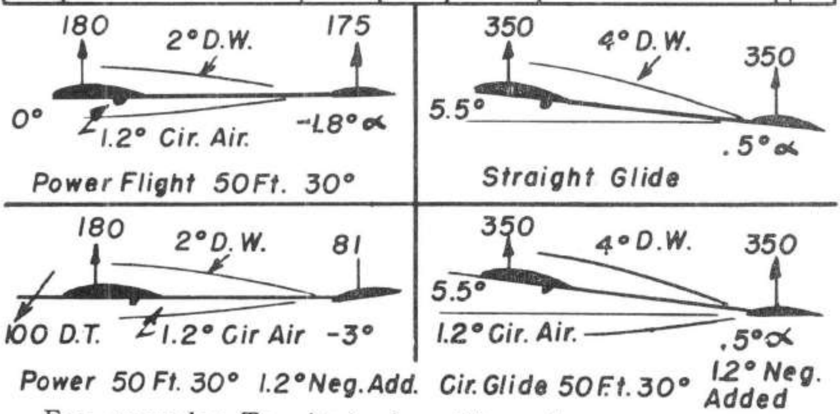
One salvation may be in making higher aspect ratio wings. Not so much for efficiency, as for torque control. Having 50″ span, means that moment arm will increase from 10″ to 12.5″ on a "V". And about 19″ for Tip dihedral. Since we will not be penalized for using high dihedral, we should not hesitate to use all we may need.

STANDARD RUBBER DESIGNS

If you like to have your model circle for thermal hunting, the 80% C.G. design will work better than the 100% C.G. The 80% C.G. model can be made to circle in a glide a bit easier. However, you will have to depend on thrustline to balance the different glide and power adjustments.



W.A.	$W.C_L$ x W.M.= W.F.	D.W.	S.A.	A.S.A.	$S.C_L$ x S.M.= S.F.	
0	.4 x 450 = 180	2°	−1°	−3°	.08 x 1020= 81	
1°	.47 x 450= 210	2.3°	0	−2.3°	.13 x 1020= 132	Wing
2°	.54 x 450= 240	2.7°	1°	−1.7°	.17 x 1020=175	
3°	.67 x 450= 280	3.1°	2°	−1.1°	.22 x 1020=225	
4°	.7 x 450= 315	3.5°	3°	−.5°	.26 x 1020= 265	
5°	.76 x 450= 340	3.8°	4°	.2°	.32 x 1020= 325	Bal.
6°	.82 x 450= 360	4.1°	5°	1°	.37 x 1020= 377	



For example: To obtain low lift under power, the model should have a spiral climb equivalent to a 50 ft. circle in a 30° bank. The positive angular change under such a condition is 1.2°. This same 1.2°, which is purposely brought about during power to bring the wing to 0°, will cause trouble in a glide of similar circle.

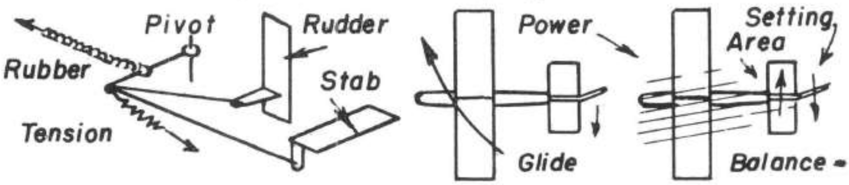
We do not want the wing to operate at 0° in a glide, but at 6°. To do so, we must decrease the stabilizer's angle of incidence by 1.2° This means that, if nothing is done to counteract it, the stabilizer will try to stall the model in a straight glide, but bring the wing to 6° if in a 50 ft. and 30° bank circle. — This also means that, under power, the model will have to develop still smaller circle to obtain additional increase of 1.2°. Therefore, by making it possible to obtain a good circling glide, the Circular Airflow angle has to be increased to 2.4°.

To preserve the original power circle or spiral, while setting stabilizer -1.2°, we can use downthrust to counteract the stalling tendencies of the -1.2° increase.

As a matter of fact, to obtain satisfactory glide, we make the same adjustments as we do on gliders. As we tighten the circle with the rudder, we bring it to floating condition with the negative stabilizer. To counteract the rudder and stabilizer glide setting, we use side thrust for rudder, and downthrust for the stabilizer.

An ideal system would be to have the pull of the rubber adjust the rudder and stabilizer according to the power in force. While power is high, the model should have 0-0 setting to achieve maximum climb in large helical climb. As the power dies down, the setting should be changed to higher lift conditions. And when power is gone, the model should be flown into a smooth circling glide.

We tried power adjustable rudder, and it works fine. Under power the flight would have large circles, but when power was out, it would circle tight. — We also tried to use extra large rudder to open up the circle under power, and then obey the tight glide setting. See plans of the "Hurry Up 210."



The action of larger rudder is as follows: When model is gliding, the turn setting has no trouble in making the model turn. But under power, the model may have 6° side drift due to torque and dihedral action. Placing this larger rudder in a 6° drift, it should be obvious that the drift will win over the turn setting. Thus, as you can see, it is possible to obtain control change with area alone.

Incidentally, this "210" model behaves very well under 75% power. It does just as it was designed to do; wide open climb, and tight circling glide. However, under full and determined wind-up, it has right spiral tendencies. If effort is made to correct this by using left thrust, the model tends to develop power stalls. Trying to cure power stalls with downthrust, we ran into high speed, ground-hugging conditions. — So, it is not to be used for super high power, or up to the last turn condition. To make it usable for high power, still more dihedral is needed. —

The above example shows the effect of high power even on models that have excessive rudder area by normal standards. High power brings about excessive side skids so that even such rudders become stalled.

POWER AND GLIDE TURNS

The glide adjustment we made for the 80% C.G., assumed that the turn will be similar for power and glide. This would mean a right circle. The reason for this is obvious. We had the stabilizer set 1.2° more negative that could be used for a straight flight. This setting, as we have shown, is actually cancelled in the 50 ft. and 30° bank turn. Having 1.2° more negative than shown on our 6° balanced condition, means that in a straight glide flight, the stabilizer will tend to make the model stall. (Under power, of course, we can use downthrust to prevent stalling.) Therefore, under no circumstances should the model change its circle pattern. If it is made to glide to the right, the power flight must also be in this direction; although it may be in a wider circle. By doing so, we avoid the change-over, from a power circle in one direction and glide in the other, in which the model would have to fly a straight course.

RIGHT POWER AND LEFT GLIDE

The basic problem with the 0-0 setting is the glide adjustment. To obtain normal size circles, the stabilizer's angle has to be reduced. But when we do that ,we automatically lose whatever advantage 0-0 setting has for high power climb. If we adjust for right glide and right power flight, the tension can be eased up a bit, since we can have the stabilizer slightly negative. But, experience does not recommend this adjustment. Too many right spirals happen under such adjustments.

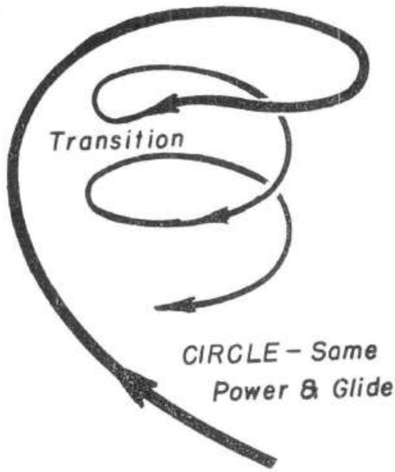
The prevailing method, now in use for 0-0 setting, is to have a right power climb and a left glide. This is done by having left rudder for the glide, and offset its influence by right thrust to obtain right spiral climb. It makes sense.

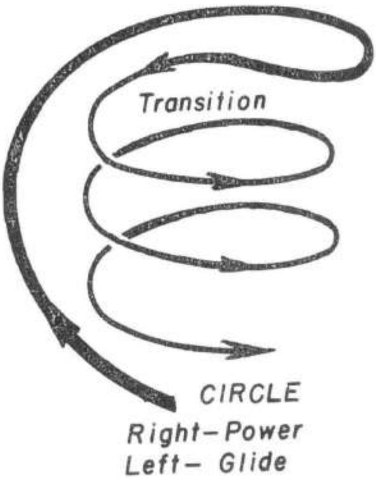
The above adjustment means that during the transition period, from right to left. the model is flying in a straight path for a moment. During this moment, it must not have any stalling tendencies. If it does stall, all the advantage of the 0-0 power climb will be lost in the next few stalling dips.

To obtain transition from right to left, without stalling, the model should be adjusted as follows: Under low power, get the model high enough to obtain a straight glide. Adjust so that it is just under the stall, but without showing any stalling tendency. This is done by shifting C.G. or adjusting stabilizer setting.

The next step is to develop the left turn with rudder only. If the turn seems too steep, back off the rudder setting. To not touch the C.G. or stabilizer setting as this change will spoil the transition period. You can only use the rudder for turn adjustment. If the circle seems too large, there is nothing you can do about it, unless you want a steeper glide.

To correct for the rudder, right thrust is applied as needed under different power conditions. — By adjusting in the manner shown. the model will not stall as it changes from right power to left glide circle.





TO FREE WHEEL OR FOLD

There is no doubt that the folder is best for reducing drag. But it has its price. It tends to introduce stalling tendency by shifting C.G. towards the rear. This shifting of C.G. is especially ticklish on the 0-0 design, where a change of 1/8" C.G. is drastic. If the model, on which folder is used, has to go from a right power cirle to a left glide, the danger of stalling in the transition period is great. Therefore, if you use folder, try to use same turn for power and glide. By doing so, the shift of C.G. due to folder is actually beneficial. As you have been shown in the Glider chapter, the C.G. was moved back as we tightened the turn.

If you are planning to use large circles, folder may cause you trouble. The prop will keep on revolving until the last turn, although the power supplied is nill. The model may actually be gliding with the prop just ticking over, when suddenly the prop folds back. The change of C.G. is sudden on a model which is already gliding. This would mean that adjustments that give correct glide with prop folded. would be on the diving side while the prop is just ticking over. —

Such, then, are the disadvantage of folder on a model that must change turn from power to glide; or has to make large circles due to 0-0 setting. Perhaps, by having hinge point away from the hub, the C.G. change will not be so drastic.

Advantages of the free wheeler? Just steady drag throughout the glide with no change of C.G.: With chances of a broken prop on landing.

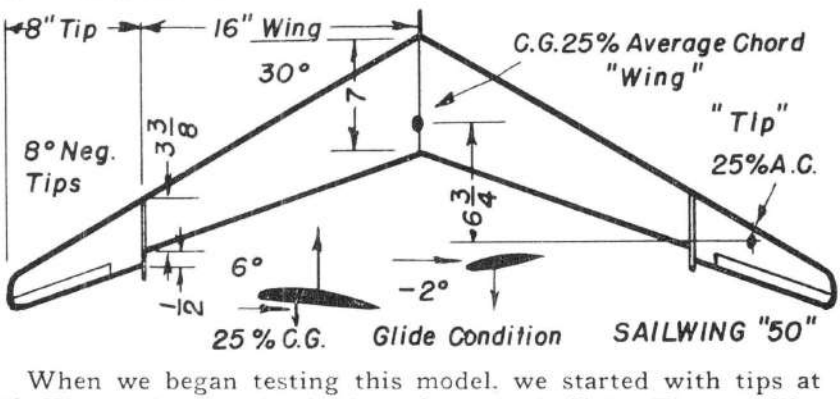
FLYING WINGS

A pure Flying Wing model would be a "flying plank." On such models the airfoil is the secret of its stability. It must have considerable amount of reflex. On such models, the C.G. must be in the neighborhood of 20%, when angle of attack is 6°, the usual for glide. — This is same as saying that about 40% of the rear portion of the airfoil is used to obtain stability. If we were to cut up such an airfoil into its functions, we would have an extremely short coupled standard design.

Such "flying planks" work nicely as gliders. They can also be power flown, but only just enough power must be used to give them a gentle climb. More power would mean looping. — We would venture that an 8 ft. "plank wing" should be powered by an .049 motor.

"SAILWING 50"

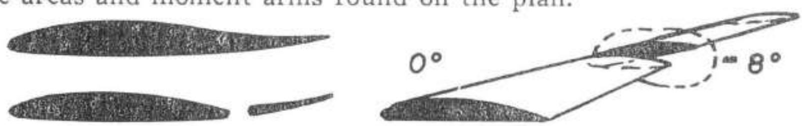
During the war, the only model we made ,while in service, was the Sailwing 50. We made it in Natal, Brazil, from where we were transferred after 20 months in Italy. Perhaps the fresh food had something to do with it, but we had no inclination to make models before. This is just a point of interest to show you that the model has been in existence for six years, so that we had no chance to make it fit our theory. — Also, since it is in a kit form, others have flown with success; much to the surprise of those concerned. In all cases reported, the C.G. was as shown on the plan. Since the kit is made so that everything clicks together, the basic layout is obtained at all times.

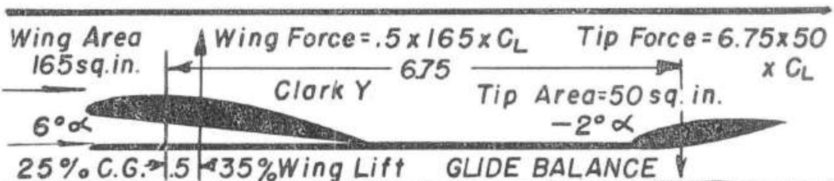


When we began testing this model. we started with tips at -4°. We would get a beginning of a smooth flight. Then oscillation started which eventually built up into a dive. — A change to -6° was made. The flight was a bit more stable, but whenever an upset occurred, it would go into the ever increasing ups and downs, and end up in a dive. We finally tried -8°. The results were remarkably changed for only 2° variation. The plan shows the basic outline.

To us, a flying wing or tailless model, is nothing else but a short coupled standard design. By making the center portion have a definite angle, and the tips follow a similar thought, the mind does not have to become twisted into mysterious knots, while wondering what happens as the angle progressively changes from center to tip. And besides, there is nothing to gain: Except an illusion that it may be a pure flying wing by blending the change-over. By assuming a definite angular difference between center and tip, we can go ahead and analyze the design in the light of what we know.

The basic layout of the "50" is as shown. The average airfoil is 6". This means that if the C.G. is at 25%, the wing lifts at 35% or about .5" behind the C.G. This would tend to nose the model into a dive. — To counteract this force, we have streamlined tips set at –8°. The Pitching Moment chart was calculated by using the areas and moment arms found on the plan.





W.A.	$W.C_L \times W.M. = W.F.$	Tip Angle	$T.C_L \times T.M. = T.F.$	
2°	.54 x 82.5 = 44	–6°	–.6 x 337 = –202	Tip swings wing to higher angle
3°	.62 x 82.5 = 51	–5°	–.5 x 337 = –168	
4°	.7 x 82.5 = 58	–4°	–.4 x 337 = –134	
5°	.76 x 82.5 = 62	–3°	–.3 x 337 = –101	
6°	.82 x 82.5 = 67.6	–2°	–.2 x 337 = –67.4	Balance
7°	.88 x 82.5 = 72	–1°	–.1 x 377 = –34	Wing to lower
8°	.95 x 82.5 = 78	0	0 x 377 = 0	

Using no downwash factor, since the tips are at the "tips", the results were as much of a surprise to us as they may be to you. The balance occurs exactly at 6°. And this is the angle which we keep on mentioning as the glide setting.

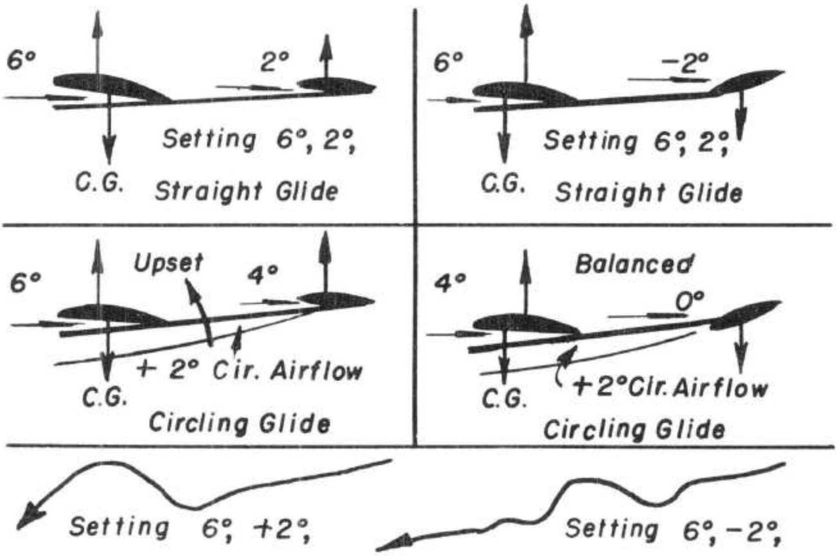
At 6°, the wing develops 67.6 units which tend to make the model dive, but the tips also develop 67.4 units which are in counter direction. The situation would look as shown while flying. Why did we have to use 8° negative? Let us see:

When we had –4° tips, the layout was as shown. When the wing had 6° angle of attack, the tips had 2°. This means that both surfaces had upward lift, and that the C.G. was somewhere between them. (Calculations placed C.G. .4" behind wing's center of lift.) This type of balance is the usual for models.

The trouble with the above balance is that it is sensitive to Circular Airflow. For example; if the "wing" was upset so that it started to oscillate or swing equal to an arc of a 25 ft. circle, the Angular Change would be 2°. This will give tips 4° angle of attack, while the wing still has 6°. The balance will be upset with the tips forcing the wing into lower angles as described before.

When the tips were at –6°, the stability was a bit better but stalls and dives still happened. It is quite possible that the C.G. was still a bit behind the wing's center of lift.

But when we moved the tips to –8°, we obtained super stability. This placed the C.G. ahead of the wing's lift. A 2° change due to Circular Airflow will bring the wing down to about 4° where it can still develop enough lift. But as a rule, the wing may never get into such position as the stabilizer is very sensitive to airflow changes, and it dampens upsets very quickly.



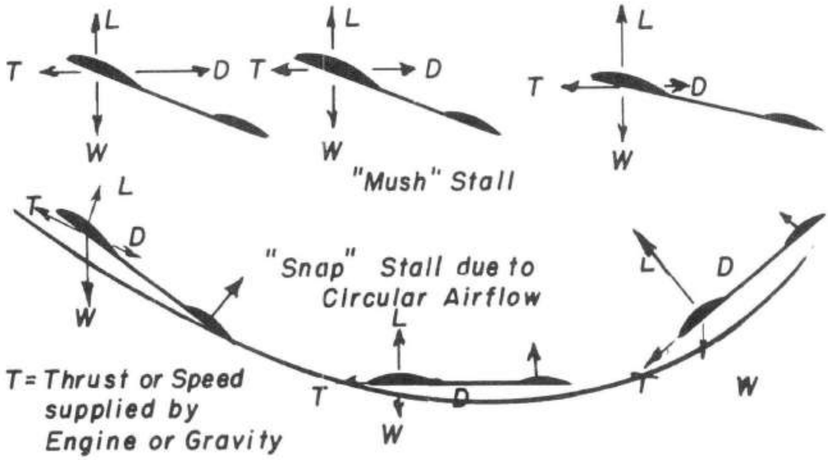
Stabilizing action of –4° and –8° tips is a sharp contrast. The –4° seem to have no control and tend to increase the size of the swing and eventual dive. While the –8° just wiggles the model into a straight flight. You will hear more about the stability of models having C.G. in front of Wing's Lift, in the Radio Model chapter.

SHARP STALLS

It might be well to show why models, having C.G. behind the wing's lift have such sharp stalls. As it was shown above in the –4° example, when the model began to zoom, the Circular Airflow tends to cut the wing's lift to nothing. It is quite possible that what we considered as a stall, is nothing else but a complete loss of lift which happens at zero angles.

We never thought of this until now. Can you see it? Suppose we have a high powered and 100% C.G. model climbing at 60°. Under power, the lift of the wing is low, but high on the stabilizer which holds the wing to low angles of attack due to Circular Airflow. Suddenly the engine stops. The wing, being at 0°, will have little life and it will tend to drop down. The model recovers by speeding up. As the wing builds up lift, it tends to nose the model upward into a zoom. But here again, the Circular Airflow comes into play: The stabilizer has stronger power and brings the wing into low or zero lift condition. The process repeats, depending on the situation.

What we may have thought was a stall, may be nothing else but loss of life due to change of Circular Airflow. A true stall is a graduall loss of lift and can be recognized by the mush. The lift value may actually be just as high, but the drag value shoots too high. In contrast we have the above sharp "stall" which indicates a complete loss of wing's lift.



POWER AND FLYING WING

The very nature of Flying Wing Stability, prevents use of high power. As we know, the wing has to move to low angles of attack when speed is increased above the glide. To bring the wing to low angles, means that we will have to apply a considerable amount of outside force to counteract the tips. For example: If we wish to bring our "wing" to 2°, we would need 158 units of downthrust. In terms of forces we know, this means 14 in. ozs., if the wing was flying at 20 m.p.h. So, if you use an .03 engine on "Sailwing 50", be prepared to mount it 5" above the C.G.

Whenever you have a desire to make a powered flying wing, use low power. If you plan to make flying wing gliders, use tips having a total area of $\frac{1}{3}$ of the main wing, and set the tips at −8°. Always make sure that the C.G. of the wing is ahead of the

35% Average Chord. If you do that, the tip angle will be automatically found for the tip area you are using. For example: If we had used larger tips on "Sailwing 50", the angular difference would be less. While smaller tip areas would need greater negative angles to balance the wing. Just consider a flying wing as a short coupled standard design, with C.G. ahead of the wing's lift for stability, and you cannot go wrong.

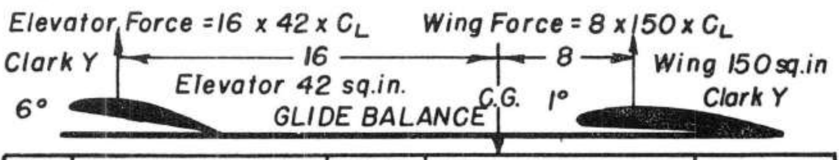
AIRFOILS IN FLYING WING

"Flying Plank" definitely requires a reflex type. When sweptback is used, you can change this reflex into Clark Y without worrying about stability. In fact, the sweptback may govern the degree of change. Say that a 15° sweptback can handle Clark Y, if you have definite negative tips. The sections between straight wing and sweptback can be the changeover from Reflex to Clark Y. If sweptback is greater than 15°, any kind of airfoil will do. As long as you have the C.G. at 25% spot, your troubles are solved. This location makes any airfoil stable, providing you have the tips to keep it there.

CANARD OR PUSHERS

The common belief, shared by the writer until now in a vague sort of a way, is that the pusher derives its stability by having its elevator stall first. Thus, causing the front to drop down to level flight. Following this logic, one would think that the elevator must be in a constant "bobbing" state, if stalling is required for a balanced flight. And under power, our old pusher used to perform the nicest loops you ever did see. No sign of stalling there.

More out of curiosity, than with expectations that it could be aerodynamically balanced, we made the calculations shown. For our example, we used Torey Capo's 1935 single pusher shown. We were not sure of the exact layout, and assumed that C.G. and angles are as shown.

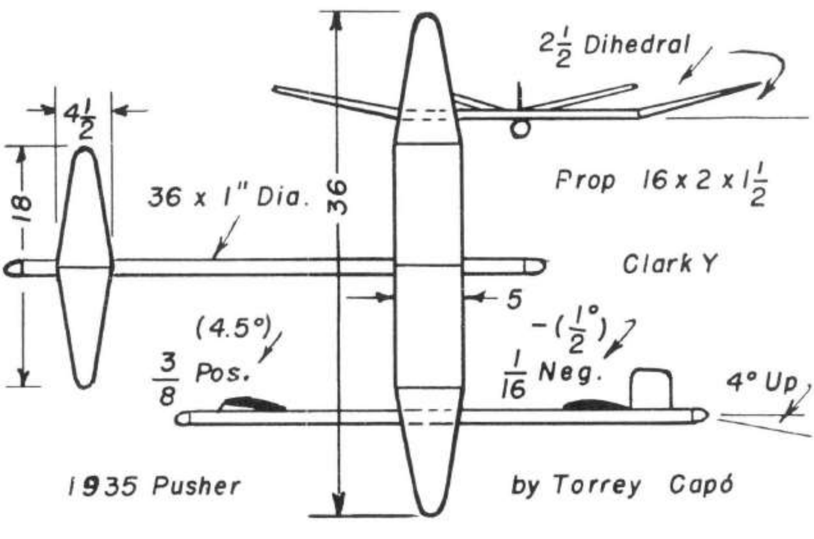


E.A.	$E.C_L$ x E.M. = E.F.	W.A.	$W.C_L$ x W.M. = W.F.	
2°	.54 x 672 = 362	−3°	.18 x 1200 = 116	Elevator swings front upward
3°	.67 x 672 = 450	−2°	.25 x 1200 = 300	
4°	.7 x 672 = 470	−1°	.33 x 1200 = 396	
5°	.76 x 672 = 510	0	.4 x 1200 = 480	
6°	.82 x 672 = 561	1°	.47 x 1200 = 564	Balance
7°	.88 x 672 = 602	2°	.54 x 1200 = 648	Wing up
8°	.95 x 672 = 637	3°	.67 x 1200 = 804	

We had to play a bit, with plus and minus, to bring the balance point at 6° angle of attack for the stabilizer. We may be off a degree on the balance point, but the balance characteristics are there. Note how the force of the wing is low at low angles, and then gradually passes the elevator's force; just as it does in our other cases. In a glide, the balance could be at the point shown. However, we have a personal feeling, that it should be at a higher angle, because as the wing does not develop much lift at 1°. But in those days, 1937, the wing loading was 2 ozs. per 100 sq. in., half of what we have today, and that 1° or 2° looks possible.

Under power, the pusher has to develop lower lift as do all other models. Our chart shows that if we want to bring the elevator to 3°, to obtain lower over all lift, we would have to give wing 150 units to bring about a balance at this angle. Note that Torey used 4° upthrust which would help the wing bring the balance to about 3°. But even if we did not use the upthrust, the Circular Airflow would do the same thing. Chart shows that the wing develops 480 units close to 0°. If we could give the wing an increase of 2° angle of attack, we would achieve the desired power balance. To obtain 2° change in a loop, the loop diameter should be 120 feet in diameter. In a power flight, such a condition would place the wing at 0° and elevator at 3°, in contrast to the 5° elevator and 0° wing incidence setting. Anyone recalling the twin pushers, will remember that they had looping characteristics mentioned.

This explanation of how the pusher works makes sense. And it should also show you why it is not good for full size planes. The arrangement lacks the super stability of the standard plane design, which has C.G. at 25% Chord. You can see that a change of only 2° on the wing brings the elevator from 6° to 3°.

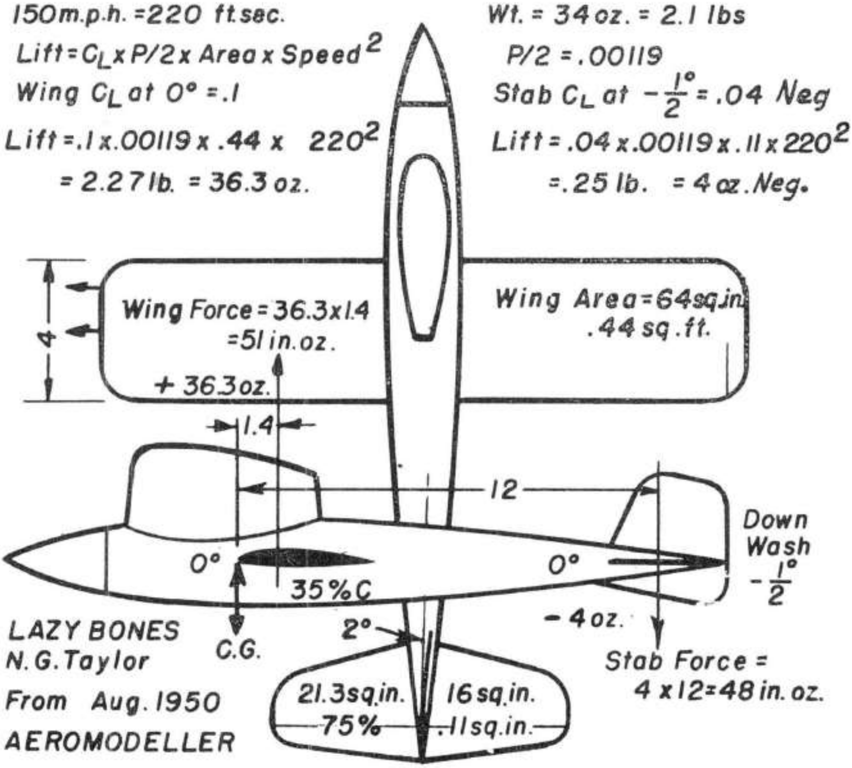


SPEED CONTROL MODELS

We wonder what "we" can tell you about Speed Control Models. Here we have been wondering what happens at 12.5 m.p.h., and you want to fly at 150m.p.h. Well, suppose we check, and see if full scale data could be used for some calculations. Let us take the longitudinal balance.

Before us we have plans of the "Lazybones III," with which Mr. N. G. Taylor established 132.4 m.p.h. official British speed record in 1950. This ship also clocked 150 unofficially. The reason we picked it, is that it had most of the data we needed on the plans. Meaning, C.G. position, approximate Airfoil, wing and stab area, and weight. The basic diagram and calculations are shown.

We worked the above problem straight. You can check. We are not sure what airfoil he used, but it looks like NACA 23012. Its C_L at 0° is .1. According to the calculation we made, it develops 36.3 ozs. lift at 150 m.p.h. when set at 0°. The weight given is 34 ozs. Close enough to make you respect formulas. The stabilizer was a bit more difficult. We assumed 75% area. — The downwash of the wing is about ½°. If we gave the flat surface a C_L of .04, which is pretty close to what a streamlined section develops, the stabilizer will develop a 4 oz. down "lift" due to the $-\frac{1}{2}°$



downwash. If the Center of Wing Lift was at 35%, the arrangement would balance very nicely. If the Center of Wing's Lift was at 30%, the stabilizer would tend to increase the over-all angle of attack a trifle. A bit of "up" elevator, would reduce stabilizer load.

Some may wonder about the stabilizer's "lift". After all, it is set at 0°. Well, if it had no download, how do you think the C.G. would stay at the leading edge? And the only way it can obtain a download, when it is set at 0°, is to receive a downwash from the wing.

This type of arrangement C.G. on leading edge, is the best suited for the condition. The angle of the wing is under complete control of the stabilizer. Meaning that wing's angle of attack will be changed with a relative large movement of the stabilizer. Thus making control "coarse" in contrast to sensitive kind. More information on Control in the Stunt chapter.

TAKE-OFF AND LANDING SPEEDS

The high speed is 150 m.p.h. What would be its take-off position and air speed? The formula solution is as follows:

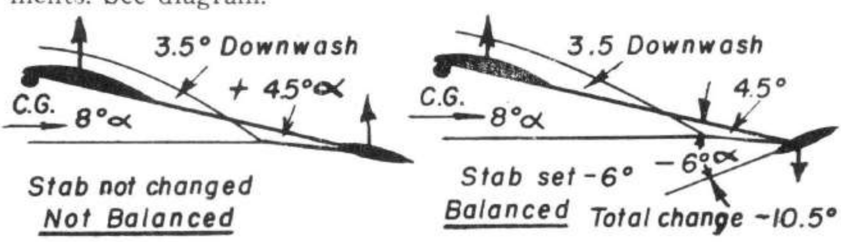
$$2.2\ lbs. = .7(C_L\ at\ 8°) \times .00119 \times .44\ sq.ft. \times (Speed\ in\ Sec.)^2$$

$$(Ft.\ per\ sec.) = 2.2\ lbs./.0003696 = 80\ ft.sec. = 54\ m.p.h.$$

The required angle of attack is 8°. What is the position of the stabilizer? It must still develop 4 oz. "down-lift" to balance wing's lift of 36.3 ozs. The formula, therefore, has the C_L as the unknown

$$Stab\ C_L = \frac{.25\ lbs.(4\ oz.)}{.00119 \times .11 \times (80\ ft.sec.)2} = .3$$

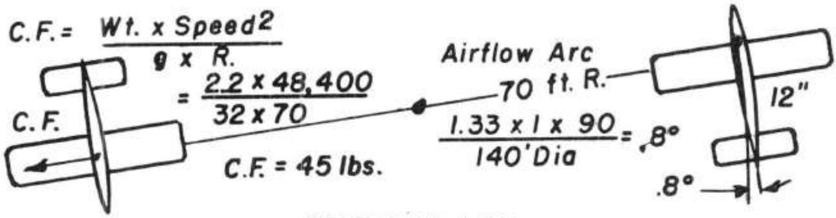
C_L value of .3 occurs at about −6°. Before we can give you the exact position of the stabilizer in relation to the fuselage or wing, we have to consider the wing's downwash. For a C_L of .7 it is 3.5°. We now have enough information to spot our elements. See diagram.



The fuselage and the wing are at 8° to the base line. The stabilizer has to be −6° to the relative airflow. The relative airflow is coming down as a 3.5° downwash. Placing −6° to this line, we have the situation shown. Adding up the angles, we see that to bring the wing to 8° angle of attack, the stabilizer actually had to be angled 10.5° Hence, our statement that C.G. on leading edge allows "coarse" control.

CENTRIFUGAL FORCE

Centrifugal Force on a 2.2. lbs. model, traveling in a 70 ft. radius at 150 m.p.h., would be as follows:



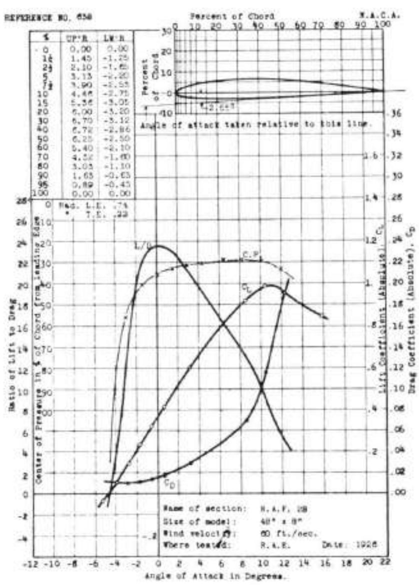
CIRCULAR ARC

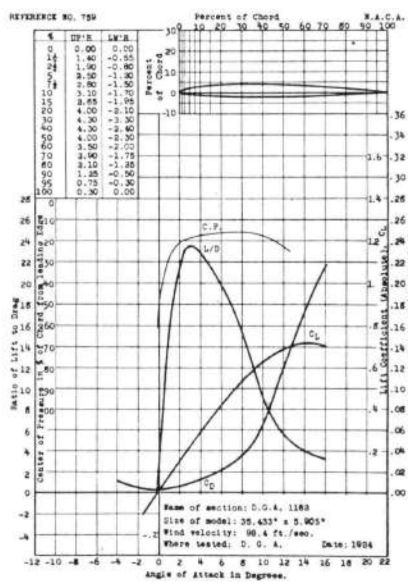
Some of you might be interested in what sort of an airflow arc the fuselage is working. Using the Circular Airflow Formula for 12" or 1 ft. fuselage, we obtain:

Assuming that the C.G. point travels on the arc, the tail end would have a .8° difference. This has the same meaning if you set the rudder for a right turn; the side area of the model is working against the drag of the lines.—

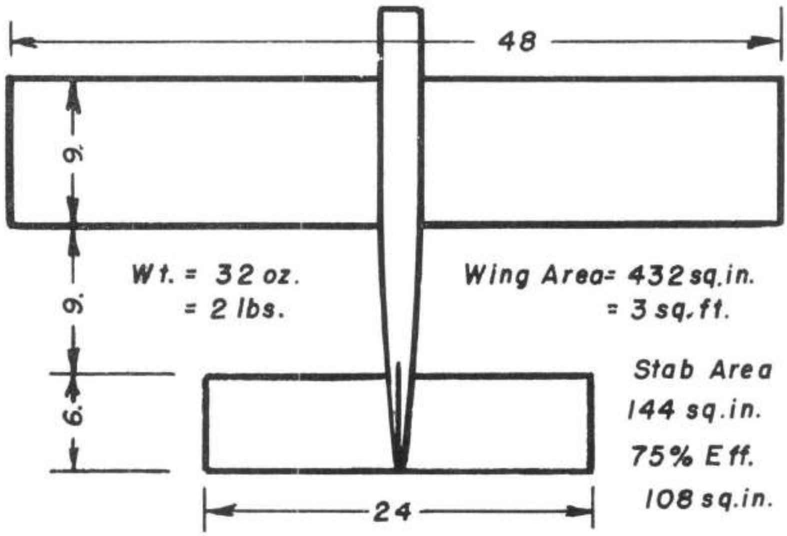
SPEED AIRFOILS

According to Little Rock speed boys, the section shown proved to be best to date. High point at 40% and about 8% thick. Leading edge about 3% above base line. This would indicate an airfoil which has a C_L value of about .1 at 0° angle of attack. This would place the fuselage in flight path.





Through no fault of ours, all we know about them is what we read in the magazines. And the impression we have is that a fair average model has 3 sq. ft. of area or 432 sq. in. and weighs about 32 ozs. or 2 lbs., and that one speed could be 50 m.p.h., and another 75 m.p.h. — And that the criterion of stunt performance is the tightness and the smoothness of the loop. Using the usual streamlined airfoil, we made some calculations that will give you an idea just what factors govern the performance.



LEVEL FLIGHT

By starting with a level flight, we can see how much leeway we have left for looping. Therefore, by using regular lift formulas, we can find the model's angle of attack in a level flight as follows:

35 M.P.H. $\quad 2\,lbs = C_L \times .00119 \times 3\,sq.ft. \times (52)^2$

(52 ft. per sec.) $\quad = C_L \times 9.7 \qquad C_L = 2/9.7 = .2 = 2°$

50 M.P.H $\quad 2\,lbs = C_L \times .00119 \times 3\,sq.ft. \times (75)^2$

(75 ft. per sec.) $\quad = C_L \times 19.9 \qquad C_L = 2/19.9 = .1 = 1°$

75 M.P.H. $\quad 2\,lbs = C_L \times .00119 \times 3\,sq.ft. \times (109)^2$

(109 ft. per sec.) $\quad = C_L \times 40 \qquad C_L = 2/40 = .05 = .5°$

The streamlined airfoils have a C_L of .1 per degree. So, the 50 m.p.h. model will be flying at 1° and the 75 m.p.h. at .5°.

LOOPING

Size of loop is determined by the Centrifugal Force. This is the force that the wing has to balance in a loop. If the weight is 2 lbs., and the model is flying at 50 m.p.h. the Centrifugal Force, in a 20 ft. diameter loop would be as follows:

$$C.F. = \frac{Wt. x\ (Ft\ per\ sec.)^2}{32\ x\ Radius\ of\ loop} = \frac{2\ x\ 5525}{32\ x\ 10\ ft.} = 34\ lbs$$

To counteract this force, the wing must develop 34 lbs. of lift while in a 20 ft. dia. loop. What angle of attack will it need? Knowing that 2 lbs. require a C_L of .1, 34 lbs. would need a C_L of 1.7. Looking up our streamlined airfoils we find that this value cannot be reached. Meaning, that if you try to force the wing into high angles of attack, to obtain 20 ft. diameter loop; you will force the wing to stall. Let us try 30 ft. loop.

$$C.F. = \frac{2\ x\ 5525}{32\ x\ 15\ ft.} = 23\ lbs. \qquad C.F. = \frac{2\ x\ 5525}{32\ x\ 17.5\ ft.} = 20\ lbs.$$

This value makes more sense. It requires a C_L of 1.2. Checking our airfoil charts again, we find that a C_L of 1.2 is possible on certain Reynolds Number curves, but not for ours. (If the Chord of our wing is 9", the Reynolds Number of our model would be 346.500 at 50 m.p.h. Let us try 35 ft. loop and see how we make out.

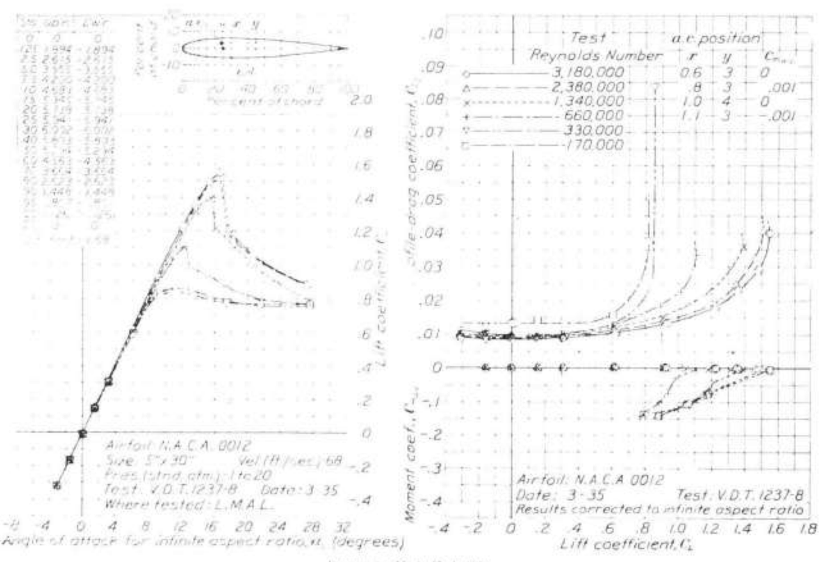


FIGURE 8.—N. A. C. A. 0012.

20 lbs. of lift will occur when the C_L is 1.0. We find this value for our 346,500 Reynolds Number on NACA 0018 chart at 12°, but not on the NACA 0012. The best that NACA 0012 can do for our Reynolds Number is a C_L of . 84 at 8°.

ANGLE OF ATTACK

In a level flight, we found that angles of attack were low. But to obtain the required 20 lbs. of lift, to counteract the Centrifugal Force, we must increase the angle to 12°, where the C_L is 1.0 — At 50 m.p.h. when C_L was .1, we had 2 lbs. lift. So, at C_L of 1.0, the lift is 20 lbs.

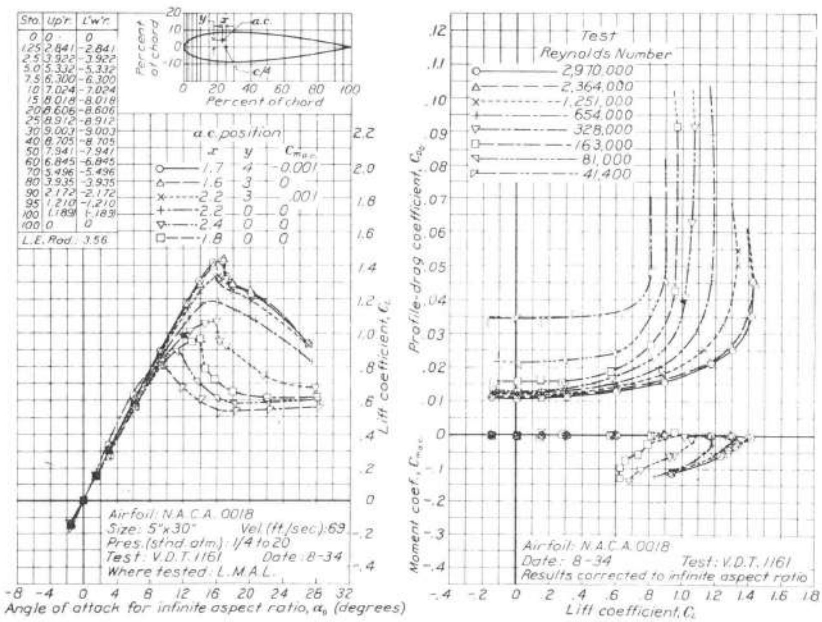
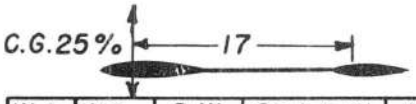
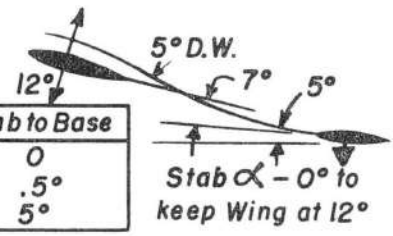


FIGURE 5.—N. A. C. A. 0018.

STABILIZER MOVEMENT

The N.A.C.A. streamlined airfoils have their center of lift at 25% Chord. So, if the C.G. of the model is at this point, the wing will have practically no force about the C.G. with which to nose-up, or nose down, the model at a particular angle of attack. This means that the stabilizer will have very little load. Or we can say that the wing will follow it without opposition. But this does not mean that the angular difference between wing and the stabilizerizer will be same at all angles. In a level flight, they are almost 0-0 to each other. As the stabilizer is set "negative", the wing will follow through, and increase its angle. As the wing increases its angle, the downwash will be greater. At our peak angle of 12°, the downwash will be 5°. This means that the stabilizer will have to take this into account. The angle of attack of the stabilizer may still be near the 0°, but its relationship to the base line is now 5°, and to the wing it is 7°. Therefore, while the wing was moved to a 12° position, the stabilizer moved only 7°.



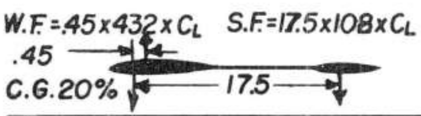


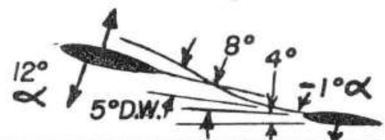
W.A.	W.C$_L$	D.W.	Stab to W.	Stab to Base
0°	0	0	0	0
1°	.1	.5°	–.5°	.5°
2°	1.0	5°	–7°	5°

By having the C.G. at 25% or center of wing's lift point, the arrangement seems more sensitive than on the speed model where a stabilizer movement of 10.5° was required to bring the wing to 8°. Let us improve this situation by moving the C.G. towards the leading edge.

MOVING C.G. TOWARDS LEADING EDGE

By moving C.G. to 20%, we gave the wing a movement arm with which to oppose the stabilizer. At 12° this wing force will

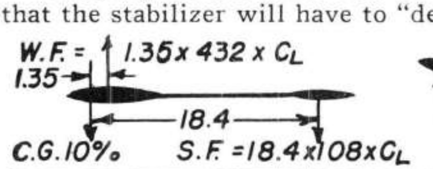


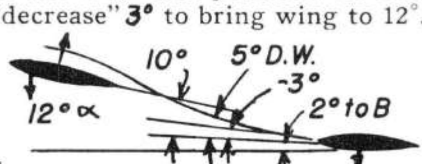


W.A.	W.C$_L$ x W.M. = W.F.	D.W.	S.C$_L$ x S.M. = S.M.	S.to B.	S.to W.
0	0 x 193 = 0	0	0 x 1900 = 0	0	0
1°	.1 x 193 = 19.3	.5°	–.01 x 1900 = –19	4°	–.6°
12°	1.0 x 193 = 193	5°	–1.0 x 1900 = –190	4°	–8°

require that the stabilizer increase its "negative" angle **1°**. Without downwash, this would mean **–1°** to base line. By adding 5° for downwash we have **4°** to base, or a difference of **8°** between wing and stab.

Carrying on the same idea to the 10% C.G. position, we find that the stabilizer will have to "decrease" ***3°*** to bring wing to 12°.



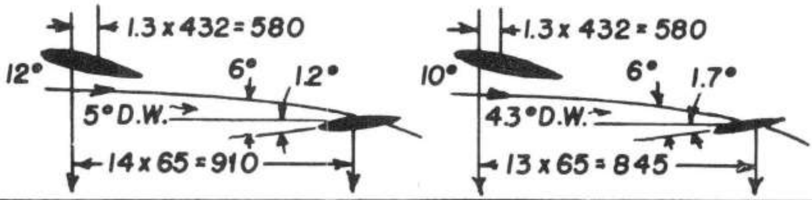


W.A.	W.C$_L$ x W.M = W.F	D.W.	A.S.A	S.C$_L$ S.M. = S.F	S.to B.	S.to W.
0	0 x 580 = 0	0	0	0 x 1980 = 0	0	0
1°	.1 x 580 = 58	.5°	–3°	–.03 x 1980 = 59	.2°	–.3°
12°	1.0 x 580 = 580	5°	–3°	–.3 x 1980 = 590	2°	–10°

This means ***-3°*** to baseline without downwash. With 5° downwash, the difference between wing and stab is ***10°***. The angle of attack on the stabilizer now is ***-3°***.

Let us see what happens if we shorten the Moment Arm to 14" and reduce Stab Area to 20% of wing. 20% of 432 sq. in. is 86 sq. in. Using 75% efficiency, we have an effective Stab Area of 65 sq. in. The Pitching Moment chart is shown with C.G. at 10% Chord.

We can see that we had to move the Stab-13° to move the wing to 12° angle of attack. This will ease up the control sensitiveness. However, we now have the Stab operating at —6.2°. It is on verge of stalling. And that is very bad. It means that we have reached the minimum loop diameter. It may do in this case as the wing is operating at its maximum angle of 12°, but suppose we did have few degrees left in the wing?



W.A.	$W.C_L$ x W.M. W.F.	D.W.	A.S.A.	$S.C_L$ x S.M. S.F.	S.to B	S.to W.
0	0 x 580 = 0	0	0	0 x 910 0	0	0
1°	.1 x 580 = 58	.5°	-.6°	.06 x 910 = 55	-.1°	-1.1°
12°	1.0 x 580 = 580	5°	-6.2°	.62 x 910 = 564	-1.2°	-13.2°

W.A.	$W.C_L$ x W.M. = W.F.	D.W.	A.S.A.	$S.C_L$ x S.M. = S.F.	S.to B	S.to W
0	0 x 580 = 0	0	0	0 x 845 = 0	0	0
1°	.1 x 580 = 58	.5°	-.7°	.07 x 845 = 59	-.2°	-1.2°
12°	1 x 580 = 580	5°	-6°	.6 x 845 = 507	-1.7°	-11.7°

WHAT HAPPENS IF THE STABILIZER STALLS

Let us assume that we have shortened the Moment Arm to 13". This will give us Pitching Moment shown. Note that the stabilizer is now at —6° while the wing is only at 10°. The wing still has 2° left before it reaches its critical point. Can we bring it to higher angles?

If we try to force the stabilizer into higher "negative" angle, to make the wing operate at higher angle, it will stall. If the stabilizer stalls, its down load is reduced. This will give the wing greater force about the C.G. which will automatically bring the model into lower angles of attack where lower lift than required is produced. Thus, if the stabilizer has reached its stalled condition, it cannot be forced to produce more "lift" with which to make the wing operate at higher angles.

Perhaps you have had the above experience. No matter how much you tried to tighten the loop, the model failed to obey your control. It may actually have "opened up" as you tried to give it the "tightest." As it will be shown, a stalled stabilizer may be more common than we suspect.

SUMMARY OF CONTROL MODEL C.G.

As you may have noted, as we moved the C.G. towards the Leading Edge, the control became less sensitive, but we also eventually reached a condition in which its maximum angle of chance, the stabilizer should be stalled, the wing will tend to nose attack. The trick, now, is to recognize this stalling point of your model, and know what it is. By knowing the condition, you will not expect the impossible. Also, you will be able to redesign your next model with different C.G. location and stabilizer area, and know what you are doing.

Incidentally, you can see from the above examples why full size planes have the CG ahead of the wing's center of lift. If by chance, the stabilizer should be stalled, the wing willtend to nose the plane down, Also, frontal C.G. position gives the plane a large margin of "safe" C.G. movement before it becomes critical in the stability department. As a matter of fact, the planes, ac- rding to the CAB ruling, must remain stable if the C.G. anges from 20% to 35% of chord. Can a lifting stab design, th C.G. at 100% and 0-0 setting, stand such a 15% C.G. change?

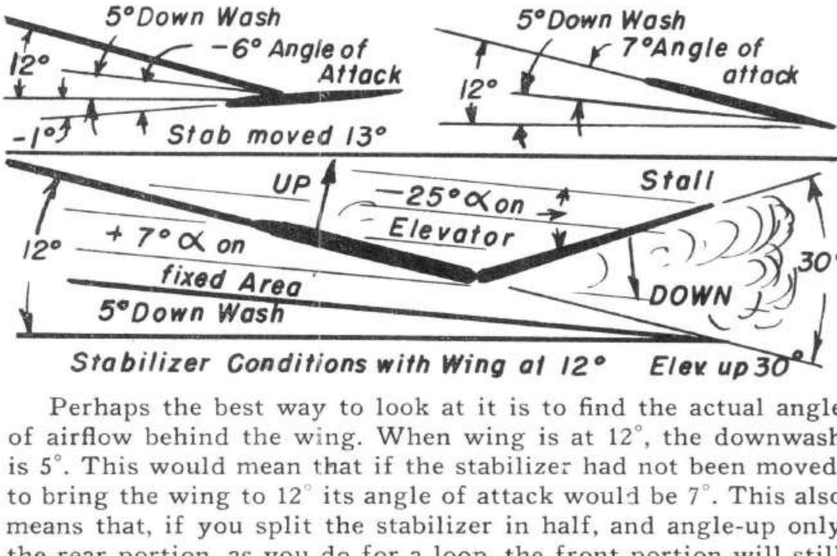
CIRCULAR AIRFLOW

As soon as the model begins to zoom or loop it will develop Circular Airflow. In a 35 ft. dia. loop, when the Moment Arm is 16" or 1.3 ft. the Angular Change will be:

$$\textit{ANGLE CHANGE} = \frac{1.33 \times 1.3 \times 90^\circ}{35} = 4^\circ$$

This means that the angle of attack on the stabilizer will "increase" by 4°. In this type of arrangement it means that the stabilizer looses downlcad. And stabilizer will have to be angled -4° to make up. — All this will happen automatically and will have no bearing on the actual stalling angle of the stabilizer. You change the angles to suit the flight. We included this so that you will have a complete picture of the flight. The stop for the stall will not change, but do not be surprised if it is 4° greater than the calculations show.

Here again we are using full stabilizer in our calculations. And when we say –6°, we mean it for the entire stabilizer. Just What sort of movement will be required for the regular half fixed, and half movable type? We do not know. On some plans we notice provisions for 30° movement. Does this mean that at times, the elevator will actually have a 30° position? — If this is so, we wonder if a stalled stabilizer occurs more often than suspected. Remember, a stalled stabilizer will still provide practically same amount of lift as it did when it began to stall, but at a terrific cost of drag. The model may actually be pulling along a regular burble of "air scramble" around the loop, and making control very sluggish. Let us make a scaled layout.



Stabilizer Conditions with Wing at 12° Elev up 30°

Perhaps the best way to look at it is to find the actual angle of airflow behind the wing. When wing is at 12°, the downwash is 5°. This would mean that if the stabilizer had not been moved, to bring the wing to 12° its angle of attack would be 7°. This also means that, if you split the stabilizer in half, and angle-up only the rear portion, as you do for a loop, the front portion will still have 7° POSITIVE ANGLE of attack. What is needed is NEGATIVE ANGLE of attack. No wonder that the rear has to be pulled up so much to get some sort of "downlcad" or negative action! — See diagrams.

This situation should make some of you think. If you have the C.G. at 25%, this kind of stabilizer control will work because the stabilizer loads required are as low as they can be. But if you move C.G. forward, greater stabilizer forces are required, and what a mess of air you may be carrying along with elevator at 45°. Well, it seems like we had better stop, as it is all theory to us. But if you have any reason for moving C.G. forward, try having larger elevator area, or its hinge point closer to the leading edge. Perhaps, as a rule you can try using a hinge at same percentage as the C.G. on the wing. If C.G. is at 25%, have the hinge at 25% of stabilizer. Anyway, give it a try, and let us know.

VARIATION OF SPEED

In our example, we used 50 m.p.h. speed in the loop, or 12°, condition. It is quite possible that, a model moving at 75 m.p.h. in a level flight, will only fly at 50 m.p.h., when at high angles. The drag difference between 1° and 12° is about five.

The lower speed naturally also means lower centrifugal force. — Let us see what would happen if we use a less powerful motor on the model, so that the looping speed would only be 35 m.p.h. What would be its minimum loop?

Dropping speed to 35 m.p.h., means that the model will lift only 1 lb. per degree of angle of attack. So you will have an idea about this airfoil, let us assume that we are using NACA 0012. Checking this airfoil, we find that we cannot go beyond 8° angle of attack, or it will stall. This means that the most lift we can obtain is 8 lbs. Placing this in the C.F. formula we have

$$8 \text{ lbs.} = \frac{2 \text{ lbs. model} \times (52 \text{ ft. sec.})^2}{32 \times \text{Radius of Loop}} = \text{Radius } 21 \text{ ft.}$$

Under the above conditions, the smallest loop that can be obtained is 42 ft. in comparison to the 35 ft. when a more powerful motor was used. The loop is larger, but the difference is not too great.

TRUE LOOP CALCULATIONS

What we have presented here is just an idea what may happen at one point on the loop. Speed may change from high, when model is horizontal, to very low when it is beginning to go on its back. But let us not get tangled up. From the information given, you should be able to see what you can do, and what you cannot or should not do.

AIRFOILS

The stalling point of the airfoil will depend on the Reynolds Number, and also on its thickness. The NACA 0018 has very good characteristics when Reynolds Numbers are high. So that it can be used on large high powered ships. But at lower numbers, its stall characteristics are bad: Sudden-like. For smaller models, having 6" chord, and flying at 35 m.p.h., it would seem that NACA 0012 has more gradual stalling characteristics. This means that you will sense the stall coming by the gradual slowing down of the model due to increase of drag at angles of about 8°.

WING FLAPS

About all we can do in this book is to give you two charts. showing the same airfoil, but in one case in combination with a flap. It means that if you were to start with the flap at 0°, the airfoil may have a C_L of .1. As you develop a loop, the flap will be depressed. If it is depressed 30° as on the chart, the airfoil will produce its maximum lift at much lower angles than normally, and the maximum C_L for our Reynolds Number, would be 1.6. Or .6 more than when no flap was used.

Although the NACA 23012 is not a symmetrical airfoil, its characteristics can be used for a streamlined NACA 0012 airfoil by shifting the angle of attack notations 2° to the left. Meaning; the 0° on chart will be 2° for NACA 0012. —

It would seem that flap combination will allow tighter looping.

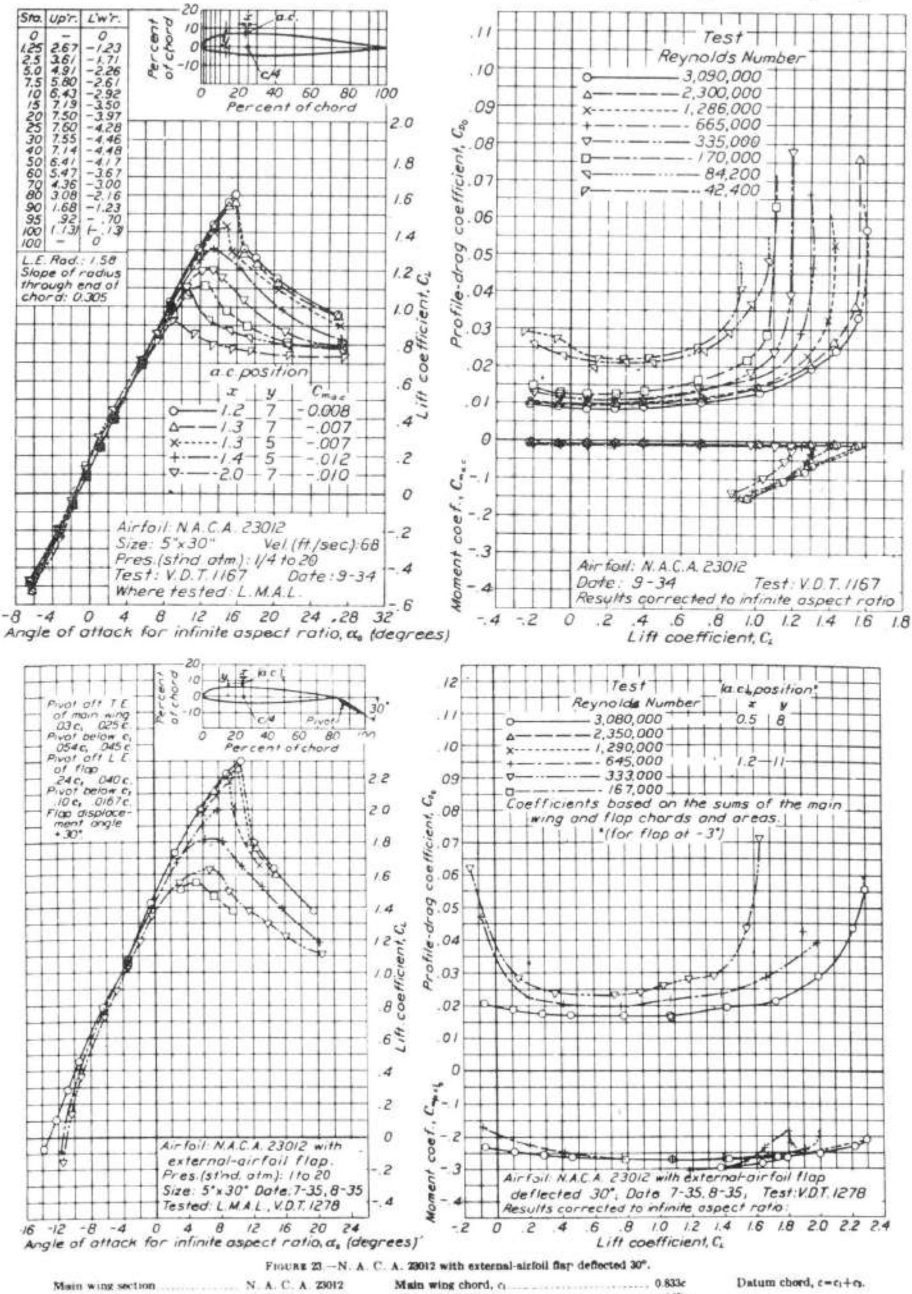


FIGURE 23.—N. A. C. A. 23012 with external-airfoil flap deflected 30°.

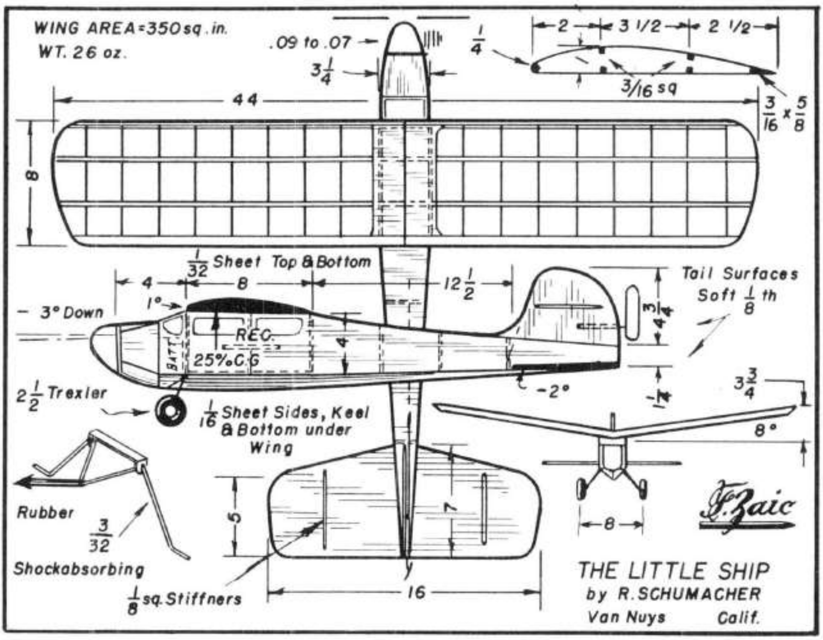
Main wing section	N. A. C. A. 23012	Main wing chord, c_1	0.833c	Datum chord, $c=c_1+c_2$.
Flap section	N. A. C. A. 23012	Flap chord, $c_2=0.2c_1$	.167c	

RADIO CONTROL MODELS

The primary problem in designing models for radio control is to maintain stability during the entire flight, power take-off, straight flight, and circling to glide landing. To give you an idea what factors determine the basic stability, we will present several designs, with different C.G. locations, and show how these locations give different flight stability.

ANALYZING

Not having a power-control model of our own on which to base our calculations, we will use Dick Schumacher's "THE LITTLE SHIP" described in the January, 1951, issue of Model Airplane News. Since Dick does not show the C.G. position, nor give us any indication of the airspeed during power or glide, we will try to find these factors just from the information we find on plans, and from theory. By showing how this is done, you will be able to do so by yourself on your own ship.



GLIDE TRIM

The first step is to determine the angle of attack in the glide. For contest models, we would not hesitate to say 6°, as we can make them circle in same direction throughout the flight. But on radio control, the model has to glide straight without stalling. This means the angle of attack must be below 6°. Therefore, 4° seems like a good choice.

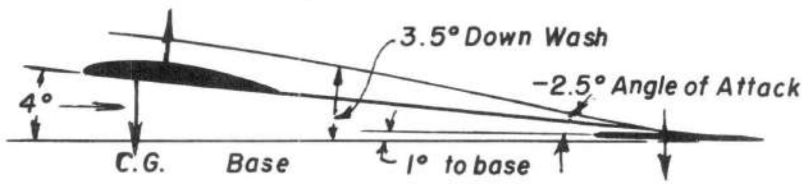
Knowing the angle of attack, wing area and weight, we can find the speed during the glide. (Most airfoils have similar lift at 4°, so that Clark Y lift values can be used) Therefore:

1.6 lb. Wt. of Model = .7(C_L at 4°) x .00119 x 2.5 sq. ft. x (Speed ft. sec)^2
(Speed)^2 = 1.6 lbs./.0021 = 800 $\sqrt{800}$ = 28 ft. per sec.
28 ft. sec. = 19 m.p.h. = Speed of model in Glide

FINDING C.G. LOCATION

Assuming 4° angle of attack for the wing, we can now find the C.G. from the information given on the plan such as: Angular difference of 3°, areas and moment arms. The first job is to find the angle of attack on the stabilizer when the wing has 4°.

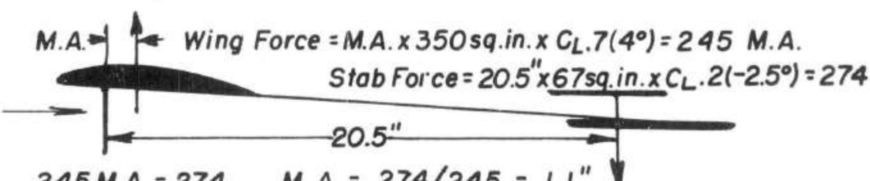
When the wing is at 4°, it has a downwash of 3.5° (C_L of .7 x 5 = 3.5°). Since we have 3° difference between wing and stabilizer, this downwash will mean that the stabilizer has a –2.5° angle of attack. This can be best explained by the diagram. We place the model 4° to base. The wing, therefore, is 4° to the base, and the stabilizer is 1°. By having a 3.5° downwash, the 1° angled



stabilizer gets a –2.5° action. Now we know that, in a glide, the wing has 4°, and the stabilizer –2.5° angle of attack. To anyone familiar with designing, this means that the C.G. is in front of the wing's lift, when the stabilizer is flat or has a streamlined airfoil.

Knowing that the C.G. will be ahead of the wing's 35% lift point, we can estimate the length of the stabilizer's moment arm. If we assume the C.G. at 25%, the arm will be 20.5″. In such a long length, plus or minus .5″ will not matter.

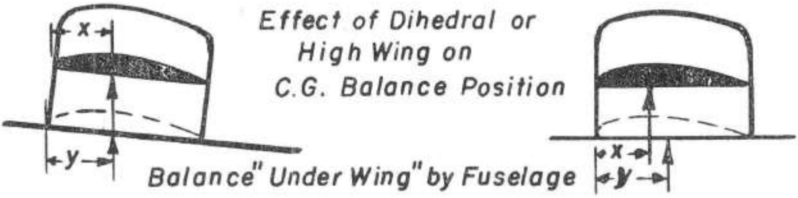
Although the stabilizer area may be 96 sq. in., we should assume it to be 70% effective, or 67 sq. in. — The only factor still missing is the wing's moment arm. This can be found from this balance equation:



245 M.A. = 274   M.A. = 274/245 = 1.1″

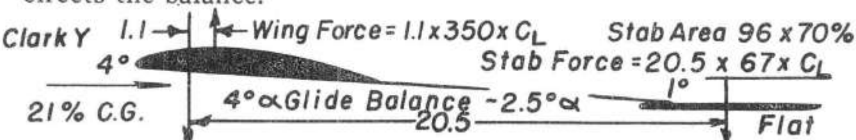
This locates the C.G. 1.1″ ahead of the wing's 35% position, or 1.7″ from the leading edge. In Chord percentage, it is 21%.

NOTE: The above was found when the model is at 4°. By leveling the model, it will be found that the C.G. point will move ¼" closer to the 35% point. — So that the C.G. point will actually be at 25% if you balance under the wing. — This is a point to remember when the Center of Lift is high above the C.G.



PITCHING MOMENTS

Now that we have the C.G. position, we can make up a Pitching Moment chart. Note that we trimmed it for 4° glide. We also made several more to give you an idea how the C.G. position effects the balance.



W.A.	W.C_L x W.M. = W.F.	D.W.	S.A.	A.S.A.	S.C_L x S.M. = S.F.	
0	.4 x 385 = 150	2°	-3°	-5°	-.4 x 1374 = -548	Stabilizer
1°	47 x 385 = 180	2.3°	-2°	-43	-35 x 1374 = -480	
1.5	.5 x 385 = 192	2.5°	-1.5°	-4°	-32 x 1374 = -445	
2°	.54 x 385 = 210	2.7°	-1°	-3.7°	-.3 x 1374 = -411	
3°	.67 x 385 = 240	3.1°	0	-3.1°	-.25 x 1374 = 363	
4°	.7 x 385 = 270	3.5°	1°	-2.5°	-.2 x 1374 = 274	BAL.
5°	.76 x 385 = 290	3.8°	2°	-1.8°	-.14 x 1374 = 190	Wing
6°	.82 x 385 = 325	4.1°	3°	-1.1°	-.1 x 1374 = 134	

FLYING UNDER POWER

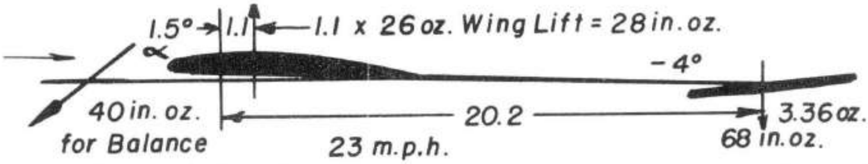
To have an easy flying model, the speed of the radio control model under power should be just slightly higher than in the glide. (Higher power speeds can be had if desired, but the model will not be so stable, and it will not be able to make tight turns without stabilizer and rudder tie-up.) Let us assume that we increased the speed of the "Little Ship" to 23 m.p.h. What will be its angle of attack now? (Remember, the lift is almost the same, under power or in the glide.)

$$1.6\text{ lb.} = C_L \times .00119 \times 2.5\text{ sq.ft.} \times (33\text{ ft.sec.})^2 \qquad C_L = 1.6\text{ lbs.}/3.25 = .5$$

STABILIZER "LIFT"

A C_L of .5 occurs at about 1.5° angle of attack on Clark Y. The question now is: How to bring the model down to 1.5° from its 4° trim? Checking the Chart, we see that the stabilizer has a very powerful download. The answer, therefore, is to provide a counter force of some kind. We can find the force of this download by use of the Lift formula. Chart shows that on line 1.5°, the angle of attack on the stabilizer is –4°. Therefore:

$$\text{Stab Lift} = .325(-4^\circ C_L) \times .00119 \times .5 \text{ sq.ft.} \times (33 \text{ ft·sec.})^2 = .21 \text{ lb.} = 3.36 \text{ oz.}$$

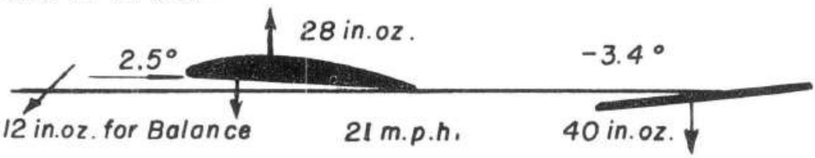


The stabilizer has a total "download" of 3.36 oz. on its 20.5" moment arm, or a force of 68 in. ozs. However, the wing has a counter "lift" of 26 ozs. x 1.1" or 28 in. ozs. We need 40 in. ozs. more to bring the model to balance at the 1.5° angle of attack.

We see that Dick used 3° Downthrust. This would mean about .5" above C.G., if C.G. was 10" away, and in line with the center of the motor. Since we do not know the static thrust of the motor, nor the exact vertical position of the C.G., we are not going to try to balance the situation. The point to remember is that, this type of lay-out, C.G. ahead of the Wing's center of lift, requires considerable amount of downthrust.

HIGH POWER

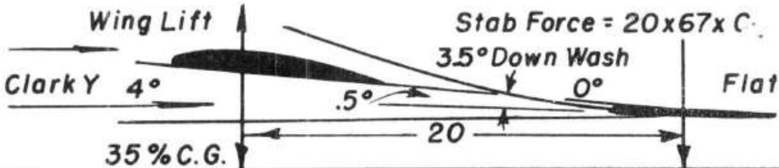
It might be well to point out, that the above "download" trouble came about because we increased the speed to 23 m.p.h. to obtain 26 ozs. of lift at 1.5°. If the speed had been increased to only 21 m.p.h., the needed 26 ozs. might have been produced at 2.5°. At this angle, the stabilizer would have a "download" of 2 ozs. or a force value of 40 in. ozs. on its 20" moment arm. The wing has 28 in. ozs. So that the –3° downthrust could handle the extra 12 in. ozs. —



Lesson from this example is to use comparatively low power when the C.G. is at 25%. If you use high power, be prepared for looping. Remember what we had to say about this arrangment in the beginning of the book. High power tends to bring such models into lower OVERALL angles of attack, in which the stabilizer has greater force about the C.G., tending to nose the model upward. — The danger comes in your trying to adjust such a model with a stabilizer to keep it from looping. The adjustment would be positive, which in a glide would prove disastrous.

35% C.G. POSITION

In this design, we find that at 4°, the stabilizer has zero lift. So that any disturbance, plus or minus will make the stabilizer bring the wing into the new airflow. To bring the model into 1.5° angle of attack, for power flying, we must still provide counter force for the stabilizer. A bit of calculation shows that at −1.5° the stabilizer will develop 1.2 ozs. On a 20″ moment arm, this means a 24 in. ozs. force: Almost half of the 40 in. ozs. required on the 25% C.G. Model. The 3° downthrust looks like it may be able to handle it, if static thrust was 20 oz. and operating 1″ above the C.G.



W.A.	W.C_L	ꝏ ꝏ	D.W.	S.A.	A.S.A.	S.C_Lx S.M. = S.F.	
0	.4		2°	−.5°	−2.5°	−.2 x 1340 −265	Stabilizer
1°	.47	Wing is	2.3°	.5°	−1.8°	−.14 x 1340= −190	
1.5°	.5	neutral	2.5°	1°	−1.5°	−.12 x 1340= −160	
2°	.57	around	2.7°	1.5°	−1.2°	−.096x1340=−130	
3°	.62	the C.G.	3.1°	2.5°	−.6°	−.048x1340=−64	
4°	.7		3.5°	3.5°	0	0 x 1340= 0	BAL
5°	.76		3.8°	4.5°	.7°	.056x1340= 75	Stab
6°	.82		4.1°	5.5°	1.4°	.112 x 1340= 150	

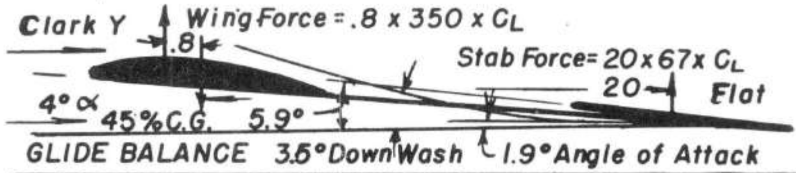
Of special interest is the angular difference. It is .5°. This was determined by the downwash at 4° angle of attack. If we wanted the stabilizer to have zero lift at this point, it must be fitted to the downwash conditions.

Note: Here again we should check on the position of the C.G. in relation to the Center of Wings' Lift. If you had C.G. at 35% spot, by checking under the wing, it will shift ¼″ towards the leading edge when the wing is angled 4°. Thus the wing will produce 6.5 in. ozs. force on ¼″ Moment Arm. To counteract it on its 20″ moment arm, the stabilizer must develop .32 oz. of negative "lift". It will do as at −.4°. So, to be true to the 35% C.G. the angular difference might be 1°.

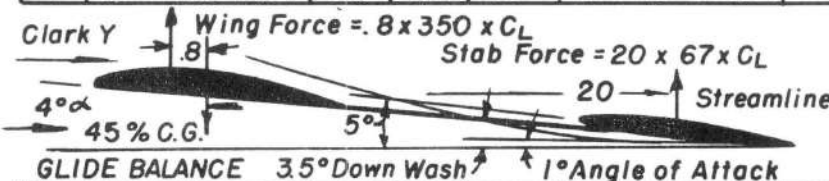
45% C.G. POSITION

We started the Pitching Moment chart by using a flat airfoil. If we used the original effective area of 67 sq. in., we found that the stabilizer would have to be set 1.4° more than the wing. We doubt if anyone will ever do that. Then we tried a streamlined airfoil. We found that it would still need 1° more incidence than the wing. But we made the chart anyway, so you can have a look at it.

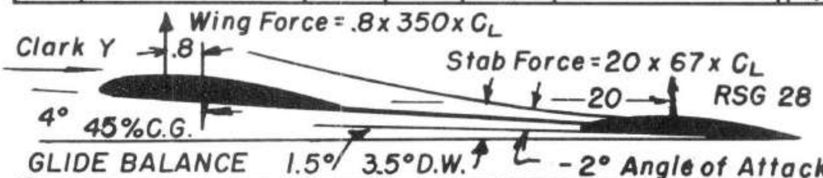
To make it more practical, we then used a regular thin section RSG 28. The situation is as shown. We find that this stabilizer can be set at 2.5° less than the wing. That is, if the wing's incidence is 2.5° the stabilizer is zero. — If you wish to bring wing down to 1.5° power flying angle of attack, you will have to use 20 in. ozs. of counter force, because the stabilizer has practically no lift at –3.5°.



W.A.	$W.C_L$ x W.M. = W.F.	D.W.	S.A.	A.S.A.	$S.C_L$ x S.M. = S.F	
1°	.47 280 = 130	2.3°	2.4°	0	0 1340 = 0	Wing
1.5°	.5 280 = 140	2.5°	2.9°	.4°	.03 1340 = 40	
4°	.7 280 = 204	3.5°	5.5°	1.9°	.15 1340 = 204	BAL.



W.A.	$W.C_L$ x W.M. = W.F.	D.W.	S.A.	A.S.A.	$S.C_L$ x S.M. = S.F.	
0	.4 280 = 112	2°	1°	–1°	–.1 1340 -134	Wing
1°	.47 280 = 130	2.3°	2°	–.3°	–.03 1340 = –40	
1.5°	.5 280 = 140	2.5°	2.5°	0	0 1340 = 0	
2°	.54 280 = 150	2.7°	3°	.3°	.03 1340 = 40	
3°	.67 280 = 174	3.1°	4°	1°	.1 1340 = 134	
4°	.7 280 = 204	3.5°	5°	1.5°	.15 1340 = 204	BAL.
5°	.76 288 = 215	3.8°	6°	2.2°	.22 1340 = 294	Stab
6°	.82 280 = 230	4.1°	7°	3°	.3 1340 = 400	



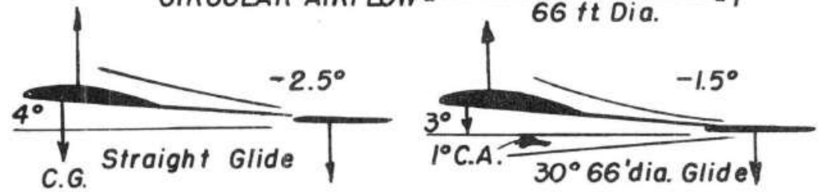
W.A.	$W.C_L$ x W.M. W.F.	D.W.	S.A.	A.S.A.	$S.C_L$ x S.M. S.F.	
0	.4 280 = 112	2°	–2.5°	–4.5°	— 1340 —	Wing
1°	.47 280 = 130	2.3°	–1.5°	–3.8°	.02 1340 = 27	
1.5°	.5 280 = 140	2.5°	–1°	–3.5°	.05 1340 = 67	
2°	.54 280 = 150	2.7°	–.5°	–3.2°	.1 1340 = 134	
3°	.67 280 = 175	3.1°	.5°	–2.5°	.12 1340 = 160	
4°	.7 280 = 204	3.5°	1.5°	–2°	.15 1340 = 204	BAL
5°	.76 280 = 215	3.8°	2.5°	–1.3°	.2 1340 = 268	Stab
6°	.82 280 = 230	4.1°	3.5°	–.6°	.25 1340 = 332	

CIRCLING

Now we come to the critical point in the story. What happens when we start the circle, and why some ships tend to tighten up the circle, instead of maintaining an even rate of descent, steep as it may be. At this point the Circular Airflow comes in. — The situation may be best understood if we assume that we are circling under glide condition.

CONDITION C.G. 25% : Our model is gliding straight ahead, with the wings at 4° angle of attack. Then we decided to make a 30° banked circle of 66 ft. diameter. Checking our Circular Airflow:

$$\textit{CIRCULAR AIRFLOW} = \frac{1.33 \times 1.7 \text{ ft. M.A.} \times 30^\circ}{66 \text{ ft Dia.}} = 1^\circ$$



W.A.	W.F.	D.W.	S.A.	A.S.A.	S.F.
0	150	2°	-3°	-5°	548
1°	182	2.3°	-2°	-4.3°	480
2°	210	2.7°	-1°	-3.7°	411
3°	240	3.1°	0	-3.1°	363
4°	270	3.5°	1°	-2.5	274
5°	290	3.8°	2°	-1.8	190
5.5°	317	4.°	2.5°	-1.5°	162
6°	325	4.1°	3°	-1.1°	134

A.S.A	S.F.
-4°	445
-3.3°	370
-2.7°	300
-2.1°	230
-1.5°	162
-.8°	90
-.5°	56
-.1°	—

New stab forces due to 1° increase by circular airflow

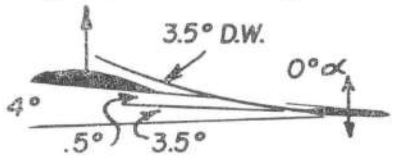
Having a change of 1°, means that the stabilizer, which was flying at –2.5°, will have a new angle of attack of –1.5°. Checking our chart, we find that this occurs between –1.8° and –1.1°. Unit value may be 160. Note the change from 274 units at –2.5° to 160 units at –1.5°. This means that the wing is stronger, and it will tend to bring the model to lower angles. Let us check it as the wing reaches 3°. Remember, we still have our 1° Circular Airflow.

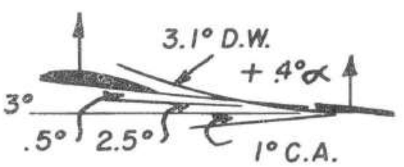
At 3°, the wing value is 240 units. Normally the stabilizer would be at –3.1°; under the new circular airflow conditions, it is –2.1°. Looking at the chart, we find that when the stabilizer is at –2.1°, it would generate 240 units. We now have a balanced condition. So, you can see that if we made the above 66 ft. circle, the angle of attack will be reduced by 1°, when the Circular Airflow develops 1° change.

UNDER POWER: The above reason will still hold. As long as the model makes the 66 ft. circle in a 30° bank, the angle of attack will decrease by 1°. So, if the wing was operating at 1.5°, in a straight flight, it will operate at .5° when it circles. The question now comes up, will the wing develop enough lift at .5°?

Assuming that the Clark Y has zero lift at –6°, it will produce 25 ozs. of lift from –6° to 1.5°. This happens through a range of 7.5°. Thus, in every degree it will develop 3.5 ozs. Since the model lost 1° of angle of attack by circling, it thereby lost 3.5 ozs. of lift. Total lift, then, is 22.5 ozs. The model may now be circling almost level if it was climbing in a straight flight. Or making a gradual descent, but should have no spiral dive development.

CONDITION 35% C.G.: A change of 1° on the stabilizer will make it "lift" more and tend to bring the wing into lower angles. Stopping at 3°, we see that the stabilizer is angled 2.5° to baseline. The 3.1° downwash is changed to 2.1° because of 1° of circular airflow. The stabilizer still has .4° positive with which to bring wing to still lower angles.





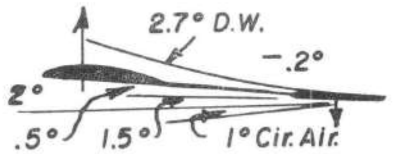
Balance Straight 4° Glide — Wing at 3° and 1° Cir. Air.

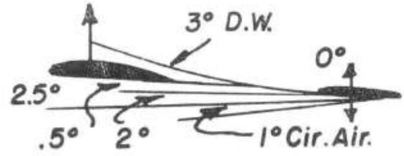
W.A.	W.F.	D.W.	S.A.	A.S.A.	S.F.	A.S.A.	S.F.
1°	Neautral	2.3°	.5°	–1.8°	–190	–.8°	–86
2°		2.7°	1.5°	–1.2°	–130	–.2°	–20
3°		3.1°	2.5°	–.6°	–64	.4°	40
4°		3.9°	3.5°	0	0	1°	108

Wing at 2.5°

0	0

Looking at the situation at 2°, we see stabilizer at 1.5° to base. The 2.7° downwash was converted to 1.7° by 1° Circular Airflow. The stabilizer now has .2° negative which tend to bring wing into high angles. We have now bracketed the balanced point between 3° and 2°.





Using 2.5° angle of attack, we have stabilizer 2° to base. 3° downwash is converted to 2° by 1° angular flow. The new downwash now flows against the stabilizer at 0°, condition required for balance.

In this layout, the model had to lower its angle of attack by 1.5° to accommodate 30° and 66 ft. circle. And still maintain a balanced condition. In a glide, loss of 1.5° is not so bad. Assuming 26 ozs. of lift, from zero lift condition of –6° to 4°, we have 2.6 ozs. per degree. So loss of 1.5° is same as 3.9 ozs. of lift. But under power 1.5° represents 5.2 ozs.

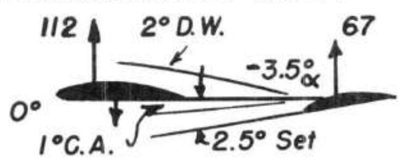
CONDITION **45%** C.G.: Changing the stabilizer angle of attack by an increase of 1°, we find the over all angle of attack moved down greatly. On the chart, we can see that when the wing has 1.5° angle of attack, the stabilizer has –3.5°. By increasing this angle to –2.5°, we have stabilizer effect as shown on line 3°. But this has 160 units, which is still too strong for the wing's 140.

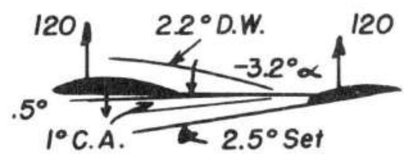
W.A.	W.F.	D.W.	S.A.	A.S.A.	S.F.
0	112	2°	-2.5°	-4.5°	—
1°	130	2.3°	-1.5°	-3.8°	27
1.5°	140	2.5°	-1.°	-3.5°	67
2°	150	2.7°	-.5°	-3.2	134
3	175	3.1°	.5°	-2.5	160
4°	204	3.5	1.5°	-2°	204

A.S.A.	S.F.
-3.5°	67
-2.8°	148
-2.5°	160
-2.2°	187
-1.5°	250
-1°	310

New stab forces due to 1° increase by Cir. Airflow

Going to lower angles, we find that at 0° angle of attack, the wing develops 112 units. Although the stabilizer has an angle of –4.5° on chart, it would be –3.5° when 1° of circular airflow is considered. At –3.5°, the stabilizer has 67 units. This means that the wing is now stronger and we can expect that balance will be reached between 0° and 1°.—





But of what use is a balanced condition when the model has to drop from 4° angle of attack to 1°. This means a loss of 3°, or 7.8 ozs. of lift in the glide. And under power, this shift from 1.5° to –1.5° would mean a loss of 10.5 ozs. of lift. It is no wonder that some of the models tend to come down real fast when we try to make them circle below their minimum circle.

SPIRAL DIVES

We have seen how a mere circle can develop a condition, in which the wing is forced into lower angles of attack. And when this is done, the trim point is moved to lower angles at which higher speeds are developed. When speed is increased, the turn setting will be more effective, tending to tighten up the original circle still more. When the circle is made smaller, the Circular Airflow angles will increase. And an increase of Circular Airflow angles, means lower angle of attack for the already very low angle of attack condition. By now the model has bounced off the concrete.

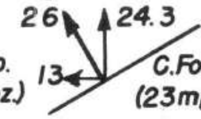
SIZE OF MODEL AND CIRCLE

In the example we used, the moment arm was 20″. In a 30° bank and 66 ft. circle, we obtained a 1° angular change. If the moment arm had been shorter, the angle would have been smaller. If it had been longer, the angular change would be greated. A 40″ moment arm would produce 2° under same 30° bank and 66 ft. On other hand, if the circle had been larger, the angular change would have been smaller. Just look at the formula and you will see why.

CENTRIFUGAL FORCE AND CIRCLE

We picked 30° and 66 ft. for the 20″ moment arm to give us a nice round number of 1°. To find the true circle, we must consider the Centrifugal Force first. Checking the 66 ft., we find the Centrifugal Force at 19 m.p.h. to be as follows:

$$\underset{(19\,m.p.h)}{C.Force} = \frac{2.6 \times 800}{32 \times 30} = \underset{(36oz.)}{2\ lb.}$$



$$\underset{(23mph)}{C.Force} = \frac{2.6 \times 1089}{32 \times 33} = \underset{(42oz.)}{2.6\ lb.}$$

The 66 ft. circle is too small. The C.F. values are too high for the 30°. A 26 ozs. basic lift force would be resolved so that 24.3 ozs. will be used for vertical lift, and 13 ozs. for side force with which to counteract the Centrifugal Force.

To satisfy the Centrifugal Force with 13 ozs. of side force in the 19 m.p.h. glide condition, we can find the minimum circle by using the formula.

$$\underset{(19\,mph)}{.8\ lb.\ C.F.} = \frac{2.6 \times 800}{32 \times Radius} =$$

$$Rad. = \frac{2.6 \times 800}{32 \times .8} = 80\ ft.R.$$

$$\underset{(23\,mph)}{.8\ lb\ C.F.} = \frac{2.6 \times 1089}{32 \times Radius}$$

$$Rad. = \frac{2.6 \times 1089}{32 \times .8} = 110\ ft.R.$$

Now we see that the actual circle is much larger. In a glide, we need a 160 ft. circle. And under power, we need 220 ft.— So that the Angular Change is not as drastic as we had pictured it for this particular model. . . . Let us find the Circular Airflow angles for these circles.

$$\underset{160\,ft.dia.}{Cir.\ Air.\ in} = \frac{1.33 \times 1.7 \times 30}{160} = .46^\circ \qquad \underset{220\,ft.dia}{Cir.\ Air\ in} = \frac{1.33 \times 1.7 \times 30}{220} = .3^\circ$$

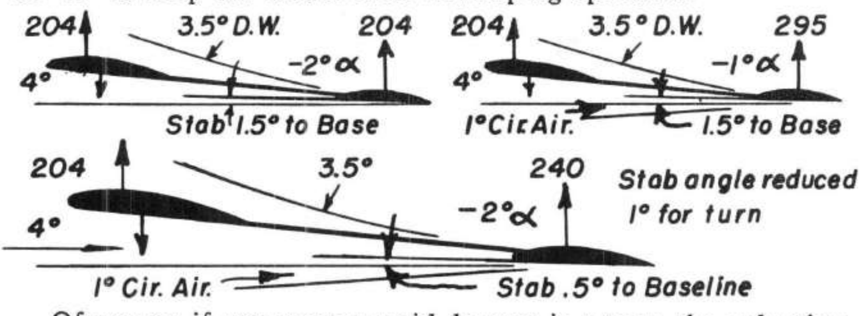
Such changes will have practically no effect on the 25% C.G. and 35% C.G. models. But they will be felt on the 45% C.G. and 55% C.G. models. Just check the Pitching Moment Charts as we have. On the 45% Chart, note the values on the 2° line. Increase the stabilizer angle by .4° and it will be –2.8°, at which it develops 147 units, very close to the wing's 150. So we can count on the change being 1.5° to 2°. In lift, this means 5 ozs. in the glide, and 7 ozs. under power.

Suppose you were not satisfied with the 160 ft. circle, but wanted smaller. The only way you can do it is by increasing the bank so that more of the lift will be used against Centrifugal Force. Making the circle smaller, will increase the Circular Airflow, and you will be working under condition we just described. So, be sure to learn all you can about this Circular Airflow theory and see how it fits into radio control.

CORRECTING FOR CIRCULAR AIRFLOW

When we have the C.G. ahead of the wing's center of lift, the change in the angle of attack, due to Circular Airflow, will not make "damaging" difference in the turn. At most, we should expect a gradual descent, if model has low power, and a steeper glide. The rate of descent and size of circle will be uniform. But for models having C.G. behind the 35% point, the Circular Airflow will make a radical change, both in glide and in power. To correct for this, the stabilizer, or its tab, should be made adjustable to compensate for this change in angle.

For example: If the stabilizer was automatically set -1°, as the model entered the 66 ft. and 30° circle, the 1° of positive Circular Airflow angle will have no effect on the 4° glide balance as shown on the chart. In a 220 ft. circle, the stabilizer change should be $-.3^\circ$ to keep the model from developing spiralitis.



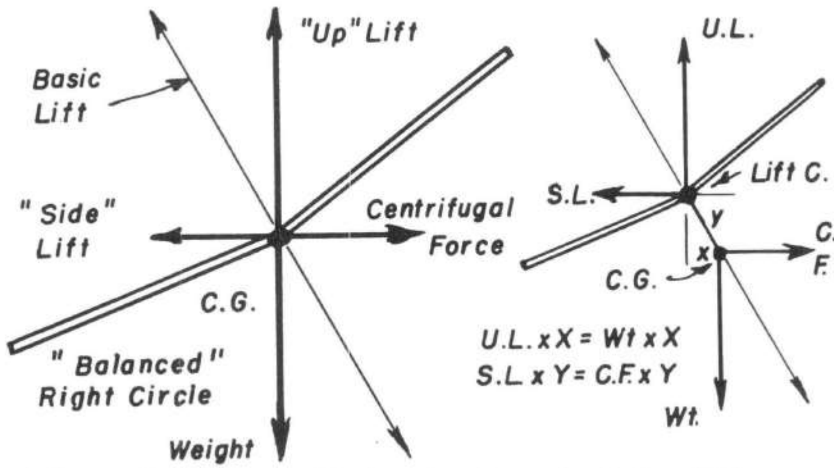
Of course, if you want a rapid descent in a turn, the reduction of the stabilizer setting does not have to be exactly as the Angular Change. You can set it $-.5^\circ$ for 1° change, and thus have results produced by $.5^\circ$ Angular Change.

Or you can have a combination. For right turn you can leave the stabilizer alone, and let the model have a steep spiral. But for the left turn, use the automatic stabilizer setting for a level circle.

On our radio control gliders, we connected stabilizer tabs to the rudder, so that every rudder turn would give us negative tabs. It worked fine. The Ruddervator works on a similar principle; automatic adjustment for compensating the Circular Airflow angles. If you use Ruddervator, the C.G. position will determine its stops.

HOW BANK IS DETERMINED

The angle to which the model must be banked is determined by the Centrifugal Force and the weight of the model. Place these two forces in a parallelogram, and you will have the required angle of bank. When the wing banks at this angle, the vertical component will take care of weight, the side component will take care of Centrifugal Force.

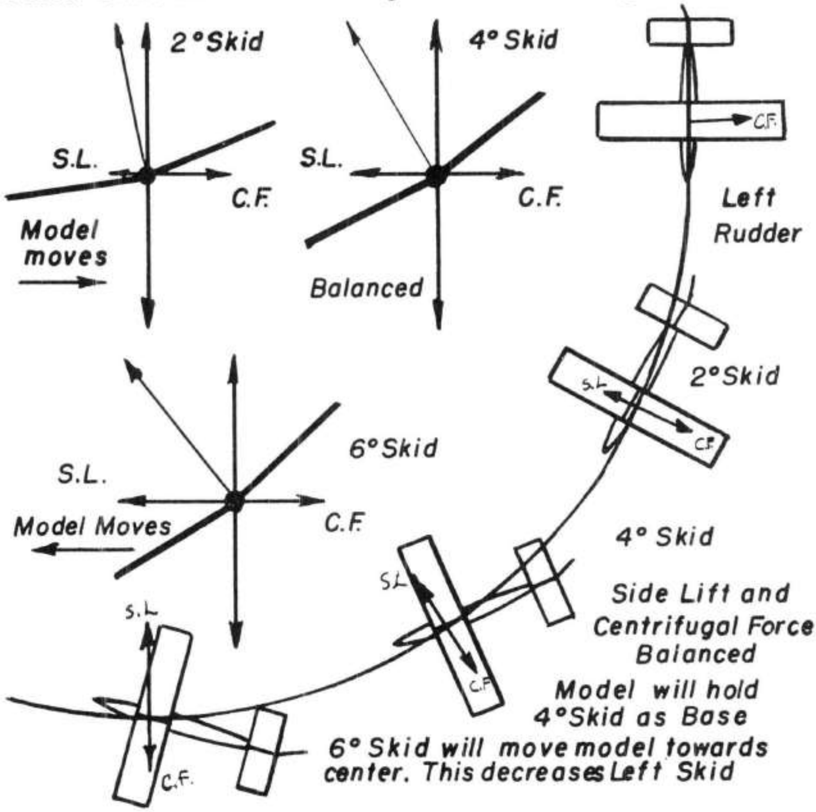


The vertical distance of the wing from the C.G. will have no effect on the situation. The balance is achieved no matter where the wing is placed in relation to the C.G.

What brings the wing to the banked position? Or should we say, what makes the wing move to the required bank and makes it stay there? We know that if we set the rudder for a right turn, the wing will bank. The question is, how much rudder is required for the job?

If the model was moving on a straight path, just a bit of "aileron" action on left wing would cause the model to start rotating. This rotation will continue as long as the setting is held. — The force required to make the wing rotate is equal to the "reluctance" of the model to rotate. For example: To start a wheel turning, you need a force. The disposition of the wheel's weight and size will determine the amount of power required to overcome the wheel's reluctance to turning. — And so it is with a model. The weight and the disposition of various parts will determine the amount of power required by the dihedral to start the wing into a bank. Thus it can be seen that a high wing will require more turning power, than one that is truly midwing.

To start a turn, we set the rudder. The rudder bring about side drifts in which the dihedral becomes effective. Say that the rudder is set for a right turn. This will cause a left skid, and so effecting the left wing. The left wing will increase the bank as long as it is in a LEFT SKID. It will continue to be in a LEFT SKID until the side force of the basic lift equals the Centrifugal Force. Once the side force equals the Centrifugal Force, a bal-



anced condition is reached. Any attempt by the left wing to increase its bank, and so increase its side force, will result in production of RIGHT SKID, because we now have more side force than we need to cancel Centrifugal Force. From now on, the model sort of jiggles from RIGHT SIDE SKID to LEFT SIDE SKID. If Centrifugal Force is stronger, the model will skid to the LEFT, and so causing the dihedral action of the left wing to produce greater bank.

From the above, you should note that, when we use rudder to produce turns, the model will be skidding out of the circle. In a vertical view it will be as shown. If you are thinking about Center of Side area, above or below the C.G., just remember the SKID directions.

This will give you an idea how a little rudder force can bring about great reactions. — Also, don't be too serious about the disposition of side area above or below the C.G. When you have dihedral, you can have plus and minus greater than you think.

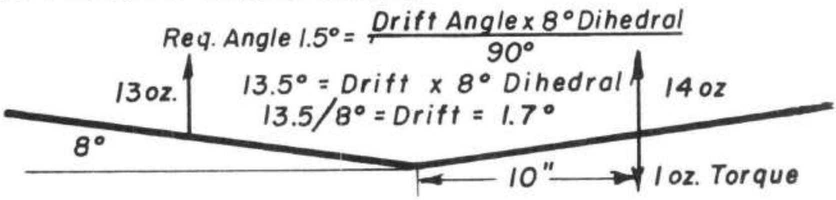
DIHEDRAL

Just for sake of record, let us check the dihedral angle on the "Little Ship" and see if it is adequate for the torque control.

Knowing that an .09 has 10 in. oz. torque, we can distribute the lift forces as shown. The right has a lift of 13 ozs. And the left has 14 ozs. so that it will control 10 in. oz. of torque on its 10″ moment arm. Here is where we get tricky again:

If the wing lifts 26 ozs. at 1°, it will lift 3.3 ozs. per degree, if zero lift is at $-6°$. (26 ozs. $\div$ 7.5° = 3.3 ozs.)

Or left wing needs only 1 ozs. of extra lift. It can do so if it has greater angle of attack. 1 ozs. represents .33° angle of attack. If the over-all angle of attack change is .33° the left wing will lift 1 oz. The angle of attack required on the left wing is, therefore, .15°. Using the classical formula:



This means that the model needs only 1.7° side drift to counteract the torque. This can be done with rudder. But the usual way is to use a bit of right thrust to keep balance in the glide. You can make similar calculations on your design to find the effect of dihedral under power.

OVER ALL DESIGN

Our main aim in this book was to present aerodynamic factors which govern a particular design. To go into construction details, would be taking up a job too great for this space. Perhaps, we may publish a book especially for radio control.

As we have shown, the basic design will be determined by your selection of the C.G. position. Once you have determined the C.G. position, the rest of the model will follow the basic rules which we presented in this book.

The fact that we picked a small model for our illustration, does not mean that the larger planes will not behave in similar fashion. It just so happens, that the reactions can be illustrated best when small forces are involved.

NOTES ON RADIO CONTROL

by Dick Schumacher

If you plan to go into R/C, you might as well forget other types of model flying, particularly if you are working on your own. The R/C problems are complex enough by themselves to demand full attention on one ship at a time if you are going to get the most out of a ship.

During the past five years 10 R/C ships were designed and built. and two other designs were flown. The models ranged in size from the original 6½ foot ship (which is still flying) down to the 33″ span model (which is still flyable). The last ship in the line is my favorite size for contest work, 5 foot span and 10″ chord. This size wing has been used on six of the 12 models flown.

The size of the model should be basically determined by the weight of the radio equipment. This weight is then balanced against the available engine size and power output. A good .049 will handle one pound of total weight: .09 about 2½ pounds; .19 up to six pounds: And a .29 should be able to fly a 7½ pound model. This power should be used in combination with wing loading of about 12 oz. per sq. foot.

As the wing loading goes up, the total weight should come down. You can see the logic of this. Although the wing loading maybe high, a light model will have lower impact force, at a given speed, than a heavier model. This seems like a paradox. but the final result is a small and light design, which can still have high wing loading.

The weight of the model also depends on the type of control used, that is, one or two channels. The weights mentioned are applicable to single (rudder) control. With two speed control, the power loading can be lowered to increase the high power performance. The curent model has a wing loading of 16 oz. per sq. foot, and its weight totals to four pounds. A two-speed K & B .19 is used. Without the two-speed control. the ship would climb too fast with this wing loading.

Personal experience seems to indicate that models should be as small as possible, based, of course, on the wing loading limits. For sport flying, a 12 oz. maximum loading is the best compromise. The model is still slow enough to keep damage to minimum. But for contest flying, a minimum loading of 15 oz. per sq. ft. should be used to get that extra speed needed to minimize wind problem. Also, a lightly loaded model cannot be trimmed too close without sacrificing longitudinal stability. These wing loadings seem to hold true down to about 42″ wings which have loading of 12 oz. per sq. ft. The 33″ ship began to show the effect of Reynolds Number fairly sharply. A 10½ oz. loading on this model made it behave like larger models having 13 to 14 ozs. loading. Incidentally, it seems that there is a trend towards designing two types of R/C models. One for sport and the other for contest. A good contest ship for bad weather will be too fast for the beginner. Of course in fair weather, a light loaded ship is just as good as the heavier type.

Size of the model and its wing loading (speed) will determine how long the ship will hold up when the going gets rough. The smaller you can build the model for a certain wing loading, and keep the speed down, so much the better. The 33″ model, with radio weight 50% of the total, has taken terrific beatings without disintegrating because it is compact and yet fairly slow. The same reason seems to apply to the 6½ footer which has had 5 years of active flying. Both models are slow although the 6½ footer cannot be termed as compact. On other hand, the 5 footer is very compact and strong, but it is beginning to show signs of wear due to the extra speed at which it is "flown" into the ground.

Aerodynamically, the designs have been held to the conservative side. There are many things that are waiting to be tried, but just keeping one ship in the air with the present equipment is enough work for spare time. However, when the ship has been exploited to its maximum possibility, it is only natural that a new design is made. One of the projects waiting for a another try is the low wing. The experience learned with a low wing R/C model lead to the conclusion that the ease of access to the equipment is not worth the fight to control the flight or to offset the construction disadvanages. The job now is to learn by experience and make a low wing model with good flight and construction characteristics.

From a construction and aerodynamical viewpoint, the cabin or shoulder wing design is preferred at present. Tail moment arm of 2.5 to 2.75 Chords seems to work well. Stab area between 25% to 33% of wing area is sufficient. While the rudder or fin area of 7% of wing can be used on "standard setups."

The aerodynamical problems of the R/C models differs considerably from the endurance free flight. In R/C we do not want "floating" glides. They tend to mess up landing accuracy, and leave us too much at the mercy of the wind and thermals. Many may disagree with these statements and prefer the "sailplane" type of flying. — Be as it may, the "Brute Force" method seems to work out. We want and need fast models to provide steady flights in gusty air, and over all good power performance. We also need a good rate of sink with power off, to get out of the air quickly and so let the next man fly, and also to get the model down with minimum of drifting glide. If two speed control is used, such a model will also have good touch and go landings.

It may seem strange but a "box" type of a model is preferred. Such a model will be easier to trim so that its speed is similar for the entire range; power climb, glide and cruise. The trouble with streamline model is that it changes speed too much and too quickly which spoils its longitudinal trim. We want a model that will not pick up speed too fast when the nose drops. We want "steady" speed. This is controlled by wing loading and aerodynamical form. The constant speed is controlled by the drag. This fact is the main reason that we do not hesitate to leave dowels, tie-on rubber and other drag producing items be exposed all over the fuselage. The fact that such things can be seen is also an advantage.

Wings have a comparatively low Aspect Ratio of 6. The reason for using this Aspect Ratio is to obtain strength and "controlled" sinking speed. Low Aspect Ratio models are easier to trim and less susceptible to C.G. changes. Simplicity dictates rectangular planform with stubby tips. At least 4° tip washout should be incorporated for greater stability. A 12-13% thick and flat bottom airfoil like Rhoade St. Genesets 33 is working out well in practice. Like most free flight fliers, we started out with 10° dihedral and were stuck with it for a long time as a change would mean rebuilding or making a new wing. Violent turn entries in the early stages were suspected as being caused by too much dihedral, but nothing was done to correct this action until we saw those uninhibited fliers from San Francisco fly ships with almost straight wings. Then, new models were made with 5° dihedral. But the recovery suffered too much. Model had to be flown out of a turn; when it should fly out by itself when the rudder is released. Also, this 5° dihedral was shy on reserve stability in the gusty air close to the ground. A move to 6° to 7° dihedral seem to be about right. The turn entry is still smooth while also getting a better recovery without aid of opposite rudder. The ship has a slight tendency to hang in the turn but that is as it should be; we are supposed to be flying the model, not the otherway around. Therefore, use 6° dihedral on fast models, and 7° on trainers or slow models. Of course, the rudder (fin) area must be balanced against the dihedral. If the model tends to hang to the turn too much after rudder has been neutralized, take off some rudder (fin) area.

Both type of stabilizers, lifting and symetrical, have been used and no particular difference was noted. The outline does not seem to make much difference, although personal preference seems to be to have straight trailing edge and sweptback leading edge.

Single rudder is prefered from strength viewpoint. Since we fly by the "beep" system, the size of the turn does not depend on the power on or off, Also, in a one "speed" model the difference in power on-off turning disappears. Control rudder of 16% of the total fin area may seem large to some, but it can be used at lower angles than smaller size rudder.

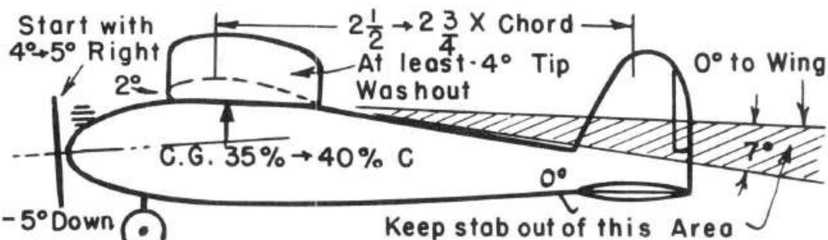
The Fuselage; At this point we can pick the subject of side area or CLA. Grant's ideas really shine in R/C, particularly with turn entries and recoveries. In R/C flying we have a definite "skid" entries into turn, and "slip" recovery out of a turn as we apply or remove rudder control. Keeping weights high and areas low seems to work out in normal procedure. Lowering the dihedral, which cuts down excessive roll stability, and lowering the CLA was a big help in the gradual development ot the series.

Another point, which may help you, is to try to keep the model in a slight skiding or underbanked condition in the turn. This will tend to keep the rate of turn more constant, and we have the returning or straightening forces that help to keep the nose up and delay spiral dive development. After all, if we have a model trimmed for a straight level flight, it is bound to come down faster if it is banked as we lose some of the vertical or total lift, due to excessive banking.

By having so much side area is another point in favor of the box fuselage. The "paper doll" method of finding the CLA may seem poor, but is works fairly close on box fuselages. On the 3rd ship of the series, the flight characteristics actually changed according to the prediction as the fuselage profile was changed with a 3 x 10 balsa sheet keel under the wing. One word of warning: Side area is not a cure-all.

Getting all the weights as high as possible will only put the C.G. as high as it can actually be, and no higher. After all, the radio weighs normally about 20-25% ot the total weight, and since it can only be shifted about 40% of the side area depth, the final effect is not as great as one would think.

The line that passes through the C.G. and CLA should slope upward. Under such condition the model tends to roll-in nose high. The horizontal axis of the CLA should also slopeup so that the model rolls-out nose low and so has a chance to dissipate a bit of speed before the nose gets back up above the horizon. You may not notice this "fine" action unless you keep a very close watch on the ship while in flight. Too many other factors of trim show stronger. But it is paying attention to many small actions that eventually pays off.



The spiral stability maybe carrying more blame than it deserves. Observations show that we have plenty of it in all normal cases. It is quite possible that there is more problem to longitudinal trim than is generally recognized. Practically every ship will start out of a spiral as soon as the rudder is released. Even the 5° dihedral model which had too much rudder at the beginning would recover quite rapidly to a safe large circle. (Too large rudder (fin) usually shows up in rough air and it is indicated by the way the mode changes heading every time a gust hits it.)

A major problem in trimming a model for R/C flying is to obtain a straight flight while the model is under high of low power, and in the glide. It is a nuisance to keep correcting the heading with "beeps" let alone with ordinary escapement. Normally the model would tend to fly to the left under power if not right thrust correction is used. The degree of right thrust depends on the fuselage shape. One of the models required 5° right thrust. Using the same wing, stab and rudder on another fuselage (2" longer and slightly different turtle back) a right thrust of 2° was more than enough.

WALTER GOOD---RUDDER BUG---Good longitudinal and spiral stability are prime requisites of the radio control model. For this size model, Frank Zaic suggested that a 25% stab would be about right for a quick longitudinal recovery. This has been verified in the air. The high lift NACA 6412 wing section is set with its bottom at 0^{0} incidence. The C.G. is at 37% of the wing chord, and the stab is set at -2.5^{0}. During tests, the C.G. was varied from 25% to 40% accompanied by the corresponding stab setting with the above figure giving the best recovery.

The good spiral stability of the model is attributed primarily to the proper relationship between dihedral and fin area, plus the "washed-out" wing tips, which reduce wing tip drag. The wing has 9^{0} dihedral in each panel. The fin area is 5%. The wing tips have a built-in negative twist of about -2.5^{0} which also helps prevent tip stall and promotes clean recovery.

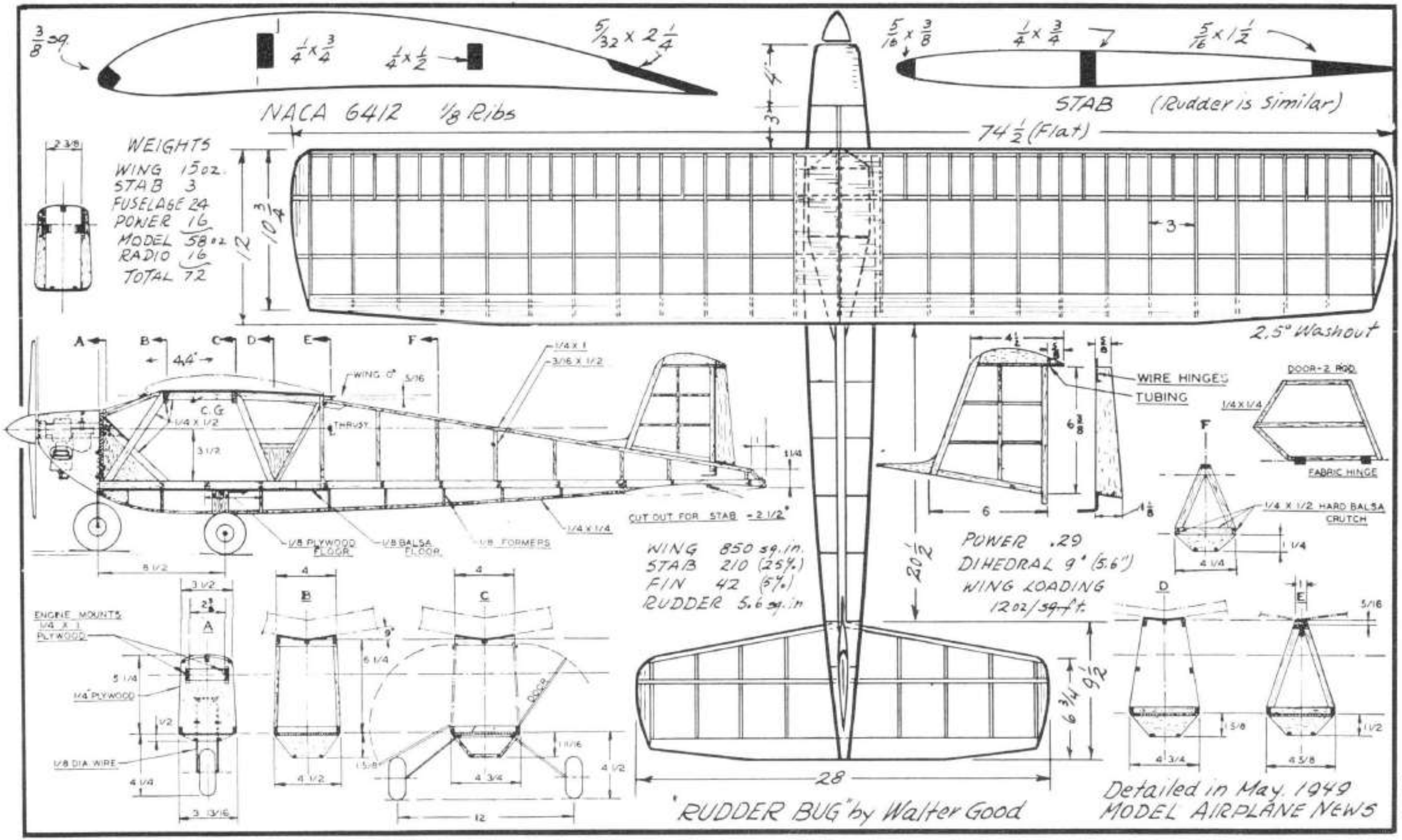
It is desirable that neutral rudder result in straight flight with engine power both on and off. Similarly, fixed left and right rudder deflections must produce equal sized circles. ---Of course, if the normal torque effects could be eliminated, the problem would be solved. A method is used here which does not eliminate the torque effects, but greatly reduces them. This type of model would normally be expected to turn to left under power. A large portion of the "left turning" torque is due to the spiralling prop wash acting heavily on the left side of the fin because the fin is usually well above the thrust line. In this model the fin has been lowered drastically such that the thrust line is directed through, or slightly above, the center of fin area. As a result, this model flies straight with no motor off-set! An earlier model which had the whole fin completely below the thrust line turned violently to the right "against the torque" with all adjustments neutral. So don't ignore the spiraling slip-stream. Gene Foxworthy has another solution by removing the fin from the slip stream and using double fins on the tips of the stab.

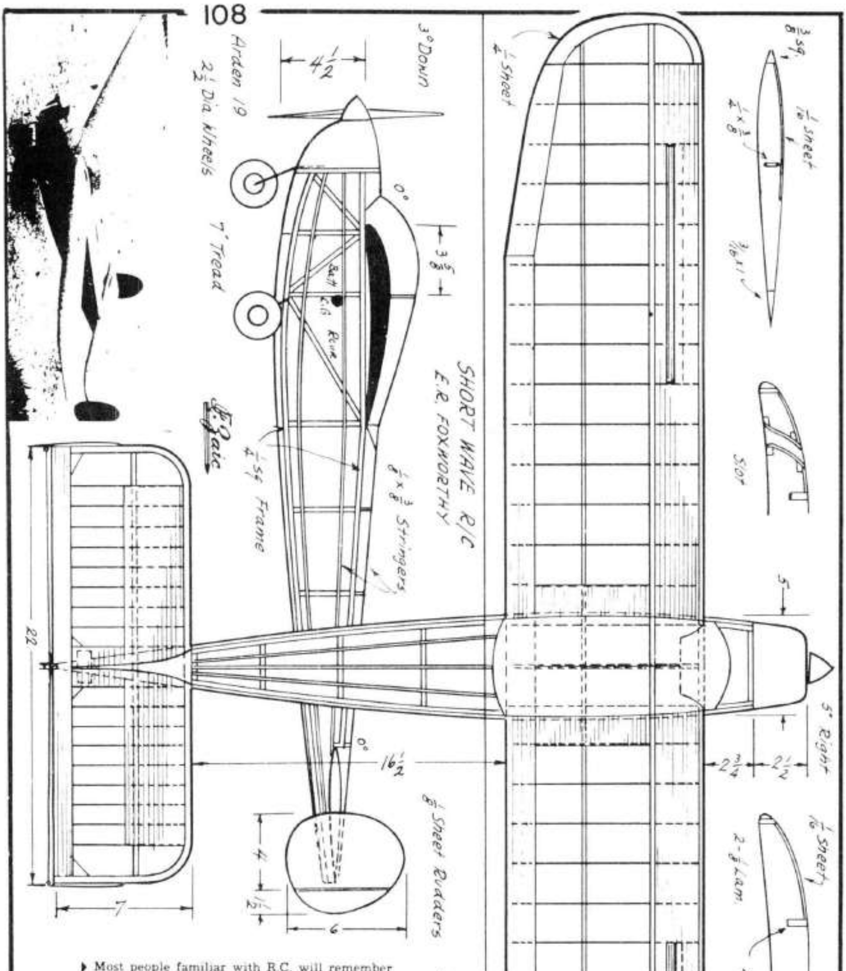
Proness of the two-wheel gear on the old GUFF to cause ground loops led us to try something different. Jim Walker's demonstration of his tricycle gear provided the answer. While all three wheels are fixed it is still possible to "steer" the model with the rudder during the take-off phase. Long, lazily realistic take-offs are made comparatively easy. Landings, too, benefit from the fact that very little bounce results, even on a hard runway. "Flat" landings have been made which exhibited no perceptible bounce followed by a terrific roll she really needs brakes! Remember the wheels absorb most of the landing shock, so choose good rubber ones, especially for the poor nose wheel!

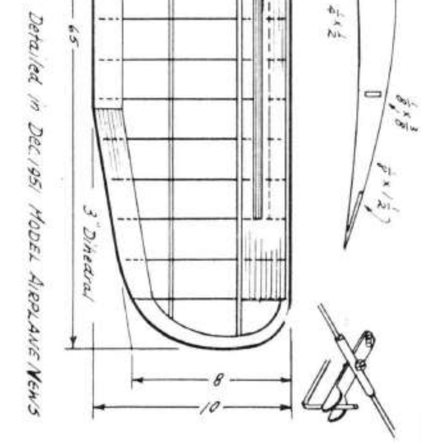
Real ruggedness is required to withstand violent maneuvers and an occasional rough landing. Experience has shown that the radio equipment is far more shock resistant than the model. So if you have to retire from the field early, it's more likely to be due to an unrugged model. Also, there is a payload aboard which stresses the model structure too. Plywood firewall and plywood landing gear platform aid the strength. The nylon covering has held up well even though two bad landings; one in a tree, the other downwind into a fence. In fact, total damage was a broken prop and a few dents. The nylon is strongly recommended.

The original model was test flown with no radio gear aboard. The purpose was to obtain approximate trim adjustments, become familiar with the model's characteristics and provide a "shakedown" test. With no payload the wing loading is about 10 oz. per square foot, which makes testing easy. Balance the model at 37% (4½" behind the leading edge) by adding weight at the nose or tail. Check the motor for no off-set. It is assumed all warps have been removed. Glide test for a clean fast glide with no sign of a turn. Alter stab and rudder setting to accomplish this. When satisfied, you are ready for power flights.

Using medium power and a 20-30 sec. motor run, try an easy hand launch into the wind. The first job is to adjust for straight glides by changing the rudder angle. Then, if necessary, adjust motor angle for straight power flights. You can stop now, but if you wish, several flights may be made with small amount of left and right rudder to observe the turning characteristics. However, remember that 1/8" of rudder is a very tight turn, so go easy!


3/8 sq.
1/4 x 3/4
1/4 x 1/2
5/32 x 2 1/4
NACA 6412 1/8 Ribs
5/16 x 3/8
1/4 x 3/4
5/16 x 1/2
STAB (Rudder is Similar)
74 1/2 (Flat)
WEIGHTS
WING 15 oz.
STAB 3
FUSELAGE 24
POWER 16
MODEL 58 oz
RADIO 16
TOTAL 72
2 3/8
12
10 3/4
3
2.5° Washout
A
B
C
D
E
F
4.4"
WING 0°
3/16
1/4 X 1
3/16 X 1/2
C.G.
1/4 X 1/2
THRUST
3 1/2
1/4
CUT OUT FOR STAB - 2 1/2"
1/8 PLYWOOD FLOOR
1/8 BALSA FLOOR
1/8 FORMERS
1/4 X 1/4
8 1/2
4 1/2
5/8
6 3/8
6
1/8
WIRE HINGES
TUBING
DOOR-2 REQ.
1/4 X 1/4
FABRIC HINGE
1/4 X 1/2 HARD BALSA CRUTCH
4 1/4
WING 850 sq. in.
STAB 210 (25%)
FIN 42 (5%)
RUDDER 5.6 sq. in.
POWER .29
DIHEDRAL 9° (5.6")
WING LOADING
12 oz/sq. ft.
20 1/2
ENGINE MOUNTS
1/4 X 1
PLYWOOD
3 1/2
2 3/8
5 1/4
1/4" PLYWOOD
1/2
1/8 DIA WIRE
4 1/4
3 13/16
4
9°
6 1/4
4 1/2
1 5/8
4
DOOR
1 11/16
4 3/4
12
4 1/2
6 3/4
9 1/2
28
5/16
1 5/8
1/2
4 3/4
4 3/8
"RUDDER BUG" by Walter Good
Detailed in May, 1949
MODEL AIRPLANE NEWS





▸ Most people familiar with R.C. will remember our old design, the Hoosier *Hot Shot*, and those who have seen the *Hot Shot* fly will remember it for its smooth performance. We have flown many types of R.C. ships, from Walker's *Hot Rod* to the *Rudder Bug*, and have never found any that compare in all around performance with the *Hot Shot*. The *Hot Shot* incorporated design features never before seen in R.C., such as twin rudders and NACA slots.

The *Hot Shot* was too stable. That statement may sound fantastic to the R.C. builder, but it is a proven fact that the *Hot Shot* could be placed in full rudder either way and never spin. It was as near a perfect example of C. H. Grant nose-up in turn design as had ever been seen. This stability was a disadvantage in contest work for any type of violent maneuvers. At the 1949 Nationals we found it impossible, even through the use of radical rudder trim, to make the *Hot Shot* spiral—

Along with the aforementioned facts, the *Hot Shot* was large, light and slow, making a poor showing in windy weather.

In the design of the *Short Wave*, we have attempted to improve on the weaknesses of the *Hot Shot* and to add some new features. The *Short Wave* is a shoulder wing design, having high thrust line and low center lateral area. We have always been students of C. H. Grant and our force arrangements are, as nearly as possible, according to the book.

We have increased the wing loading on the *Short Wave* design, bringing it up to one pound per square foot, and have used a thin section to get the speed up. Though 16 oz. per square foot is not heavy as R.C. ships go, this design has met with our fondest hopes for speed.

By acquiring the extra speed in the *Short Wave*, we have increased the overall performance with respect to the wind, but still retain the desirable stability turnwise found in the *Hot Shot*.

The theory of the twin rudders is to keep the rudder area out of the propeller slip stream, making it possible to obtain the same turn rate, power-on and power-off—assuming a fairly constant power-on, power-off flying speed.

The power-on speed can be adjusted by engine adjustment and downthrust. The glide speed is controlled by the angular adjustment of the wing and tailplane, assuming the center of gravity remains controlled.

The wing slots are used primarily to prevent tip stalls at high angles of attack and slow panel speeds. By close observation, one will notice that the average R.C. job skids while making a turn. To those readers who are familiar with the operation of large aircraft, it is obvious that the application of an extreme amount of rudder only causes a skid or a turn about the vertical axis without the necessary bank. This skid action produces two undesirable effects which must be controlled for the maximum in stability.

The first effect is the upsetting force caused by the famous pendulum effect with a low center of gravity. The skid throws the Cg pendulum out, tending to roll the plane about the lateral axis. This effect can be controlled by two means or by a combination of two, namely high Cg and proper placement of the center of lateral area.

The center of lateral area is a center of balance of the entire area of the airplane, made up of the fuselage side fin and rudder dihedral area, wheels, etc., or all areas resisting movement of the airplane sideways.

When the center of gravity and center of lateral area are in proper balance, the pendulum force is cancelled.

Another, and seldom recognized force set up in a skid, is the stall of the wing panel on the inside of the turn. This can be explained as follows:

A wing surface moving through an air stream provides an equal amount of lift on each panel. By rotating the wing panel about its vertical axis as in a skidded turn, the inboard panel is slowed and the outboard panel is speeded up, with the corresponding unbalance in lift. It is obvious that the inboard panel tends to stall, while the outboard panel tends to increase its lift, thus causing the nose to drop increasing the speed in an attempt to regain the overall loss in lift. The increased speed intensifies the skid, which further accentuates the unbalanced condition until a violent spiral results. This panel stall can be corrected in two ways, namely with slots and tip washout (the warping of the wingtips up).

It becomes evident that it would be impossible to completely eliminate the loss of lift on the inside panel, even with the use of slots or washouts, so it is necessary to go back to the big secret of spiral stability, namely the position of the center of lateral area. As covered previously in this writing, the balance of Cg and CLA would eliminate pendulum effect but to balance the forces to maintain a level turn, we must introduce a force resisting the loss of lift on the inside wing panel. This can be accomplished by placing the center of lateral area in a position where it actually causes the nose of the ship to rise in a skidding turn, increasing the angle of attack, and thus increasing the lift to a point of maintaining level flight in a turn. This can be accomplished by placing the CLA at a position to the rear and below the center of gravity.

It is very possible to design the model with the near perfect force arrangement, but as we said previously, this near perfect force arrangement was the undoing of the Hoosier *Hot Shot* in that its ability to spiral was nil.

The *Short Wave*, when trimmed properly, will make 270° of turn before any nose-down tendency is noted; then it will take another full turn to get into a full spiral.

The entire ship is covered with Japan silk. Contrary to popular belief, it is very easy to cover with silk or light nylon. Before attempting to cover, you should dope the entire frame work of the ship; then wet the cloth and pull tight over the surface. Before the cloth is dry, use a mixture of dope and glue around the edges of the frame, rubbing in until the cloth is fastened securely. Take a sharp razor blade and trim off the excess, then dope the raw edge and smooth down the edges with the finger.

After all surfaces are covered, apply about six coats to fill the cloth pores. It is essential that the wing and stabilizer be pinned down during the last two coats of dope to prevent warping. If the wing and stabilizer are left pinned down for twenty-four hours after application of the last coat of dope, there is little danger of warpage.

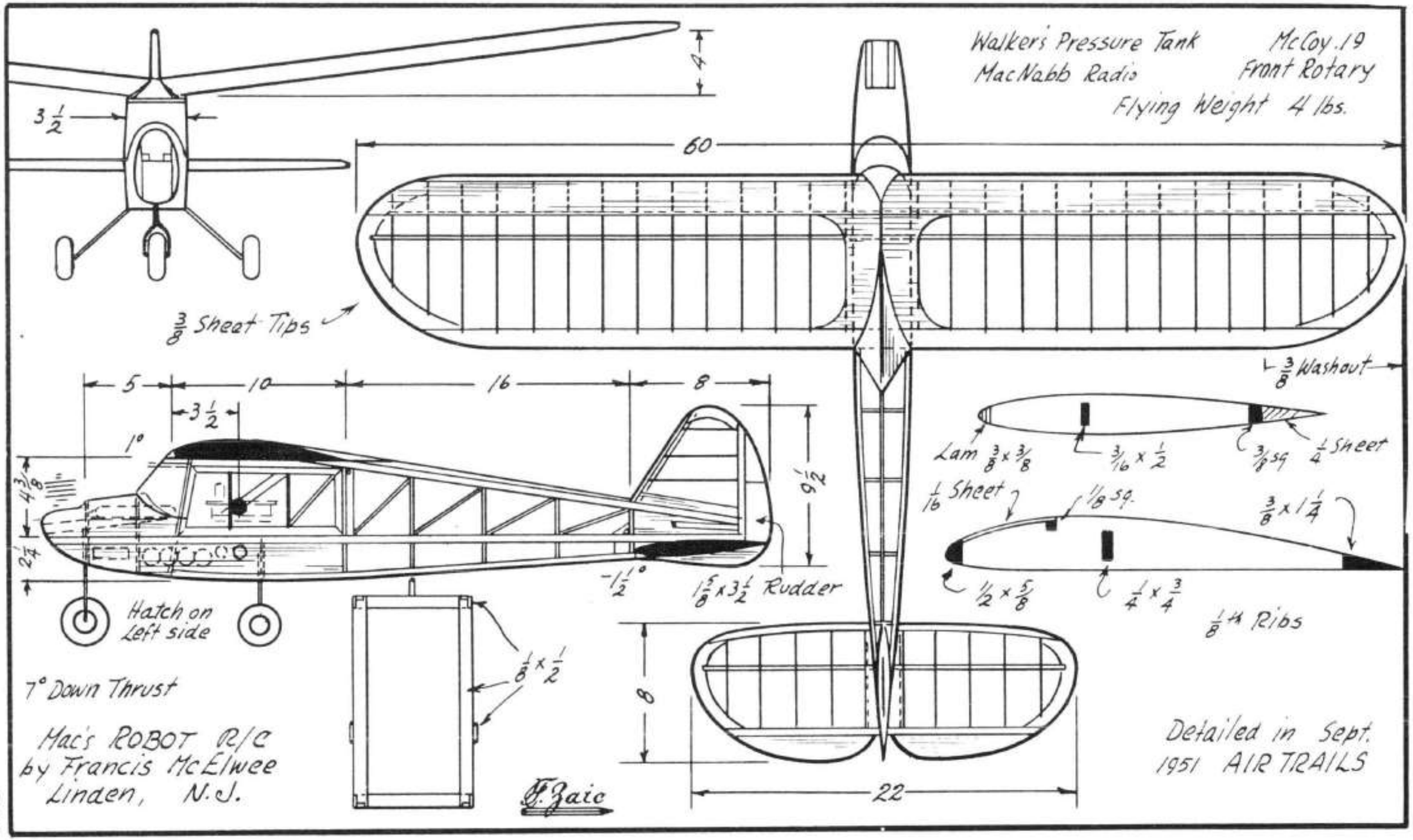
The plastic canopy was formed from a piece of 1/32 sheet plastic. We made a form from a large balsa block shaped to the proper size. Take the plastic sheet and heat it in an oven about 300 degrees until it gets very soft; pull the plastic over the form and clamp down to a bench until cold. This job can be performed very easily.

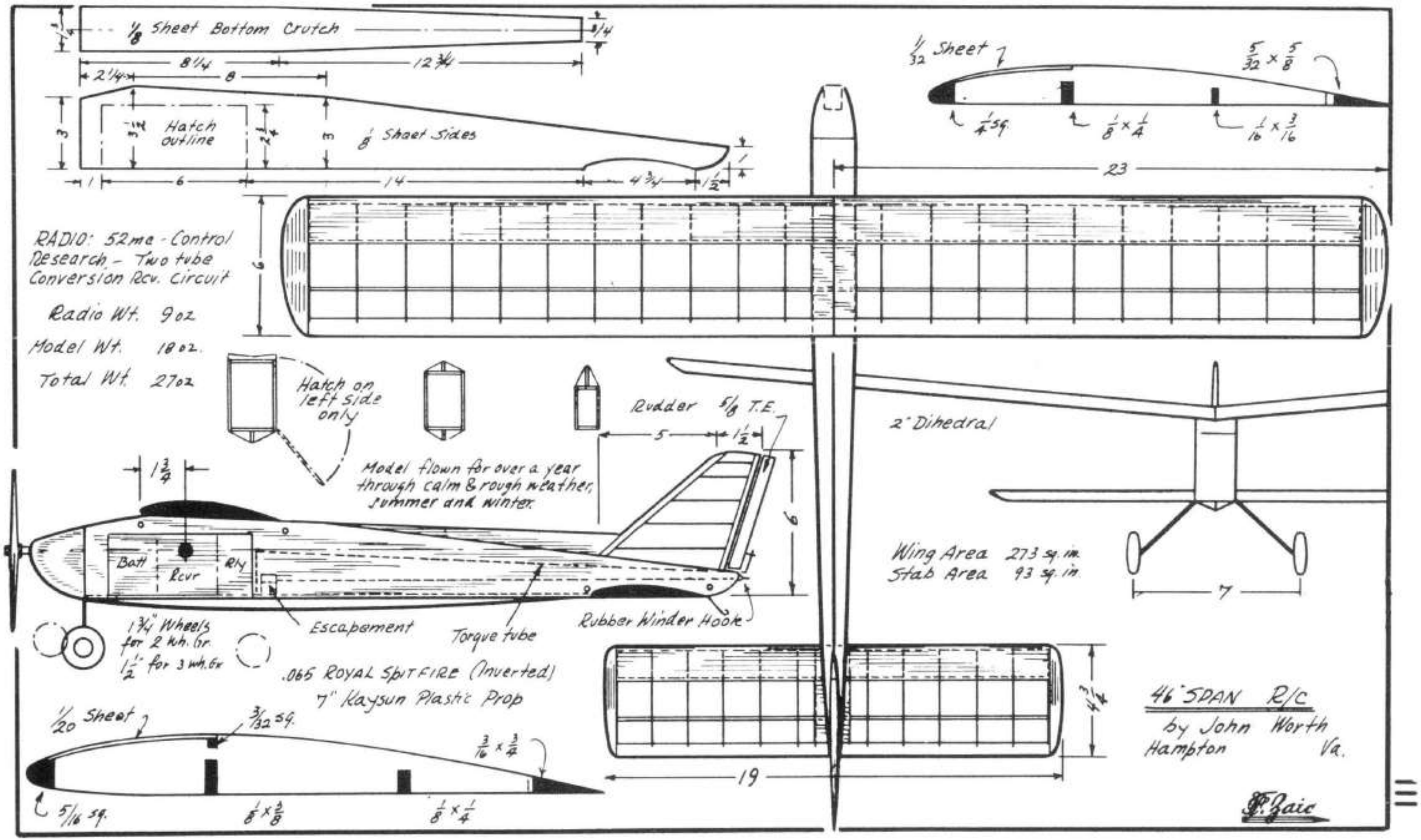
The test flying of the airplane is the same as with any other. Make sure the balance is as indicated on the plans. The angular setting of the wing and tail assembly should be correct.

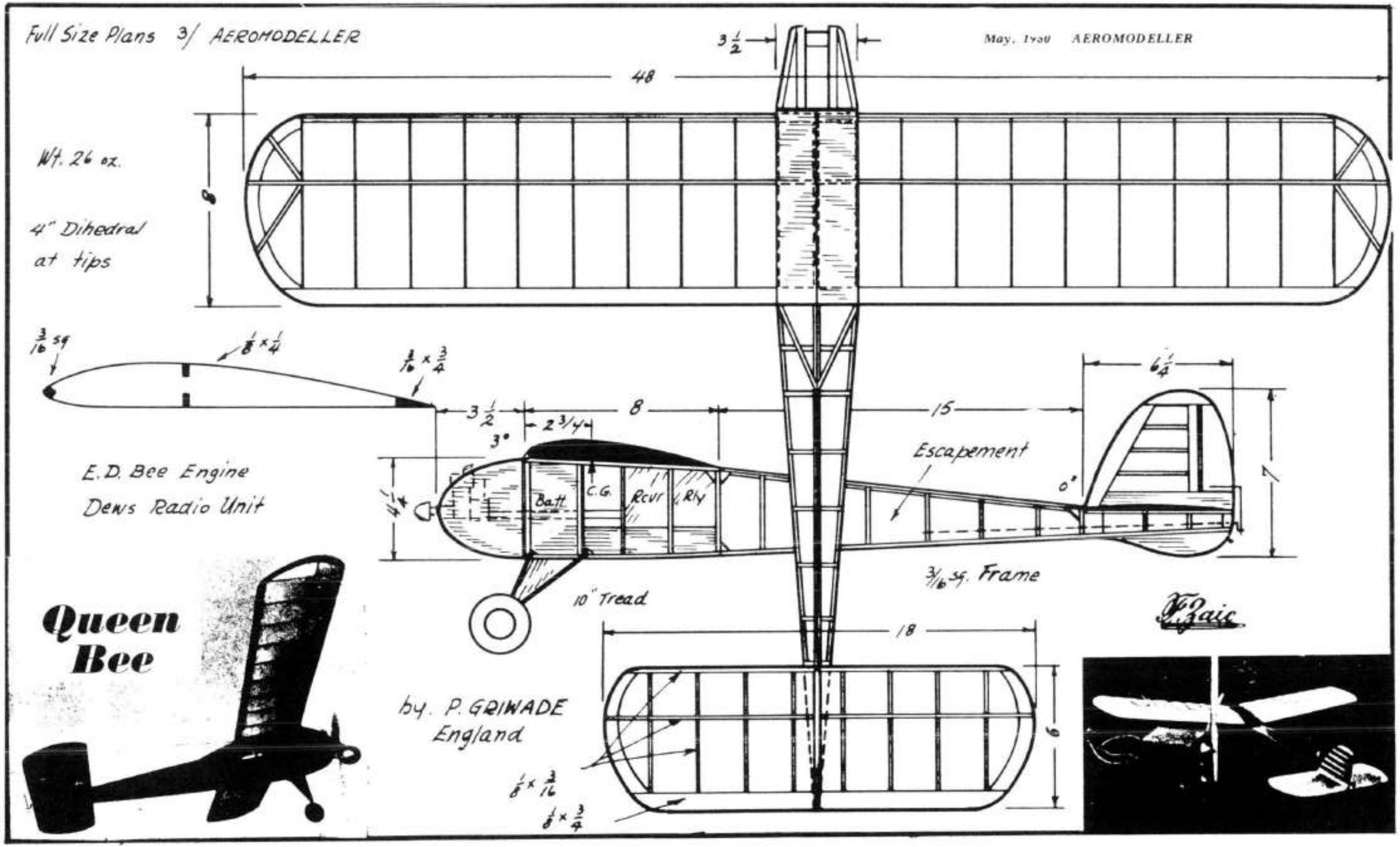
We always find it advantageous to glide the ship before power flights. Find a field with tall grass and let her go. This ship glides fast and flat. Care should be taken to see that the ship glides straight before power flight.

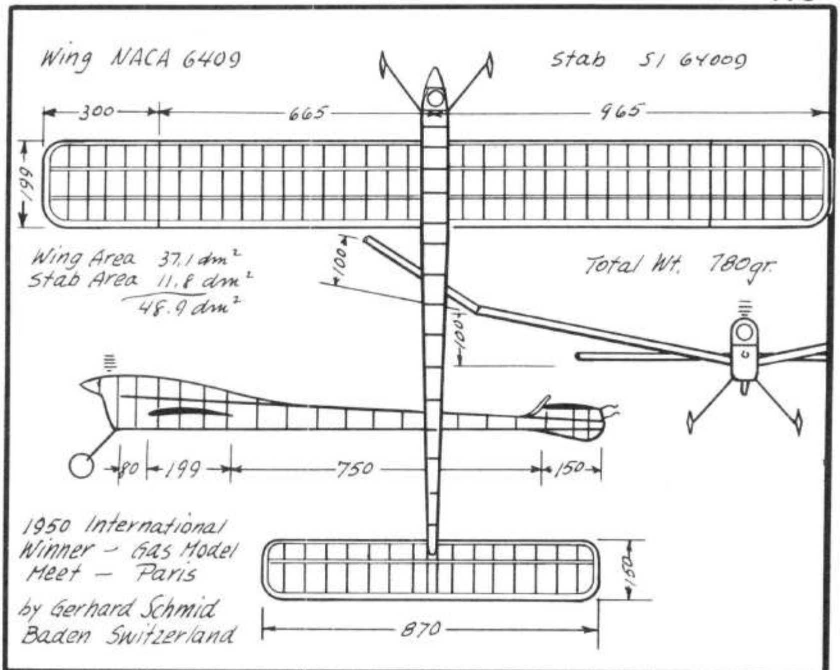
Now power flight. Some builders prefer to fly their ships without radio equipment in the initial testing but we don't agree. We have found it advantageous to have the radio working. The *Short Wave* airplane was saved from a bad crash on its first flight by having the radio on board.

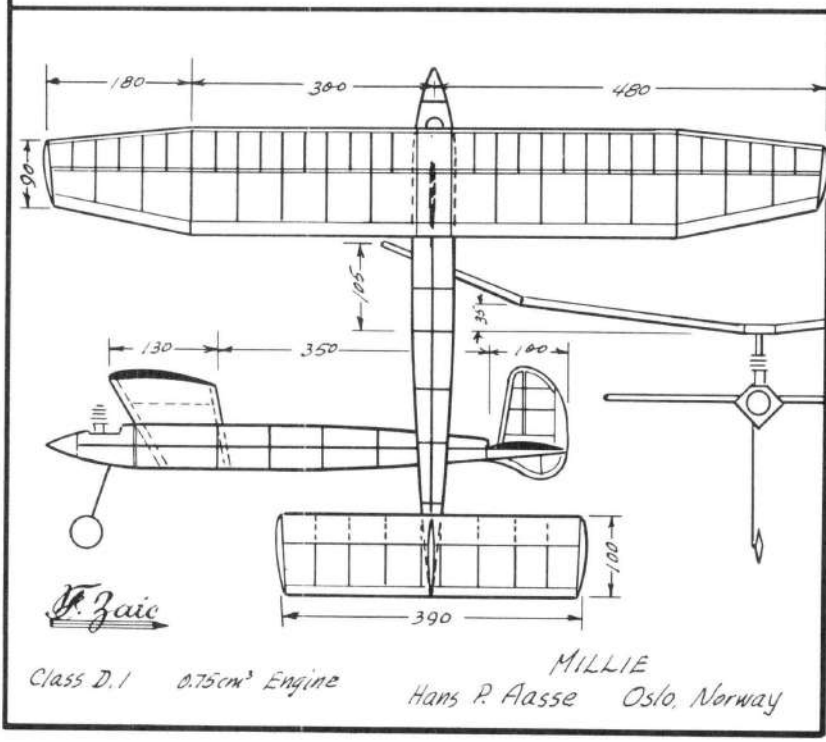
Unlike our instructions, the writer flew the plane with a bad rudder adjustment on the first flight and the plane would have surely spiraled in if the radio had not been on board.

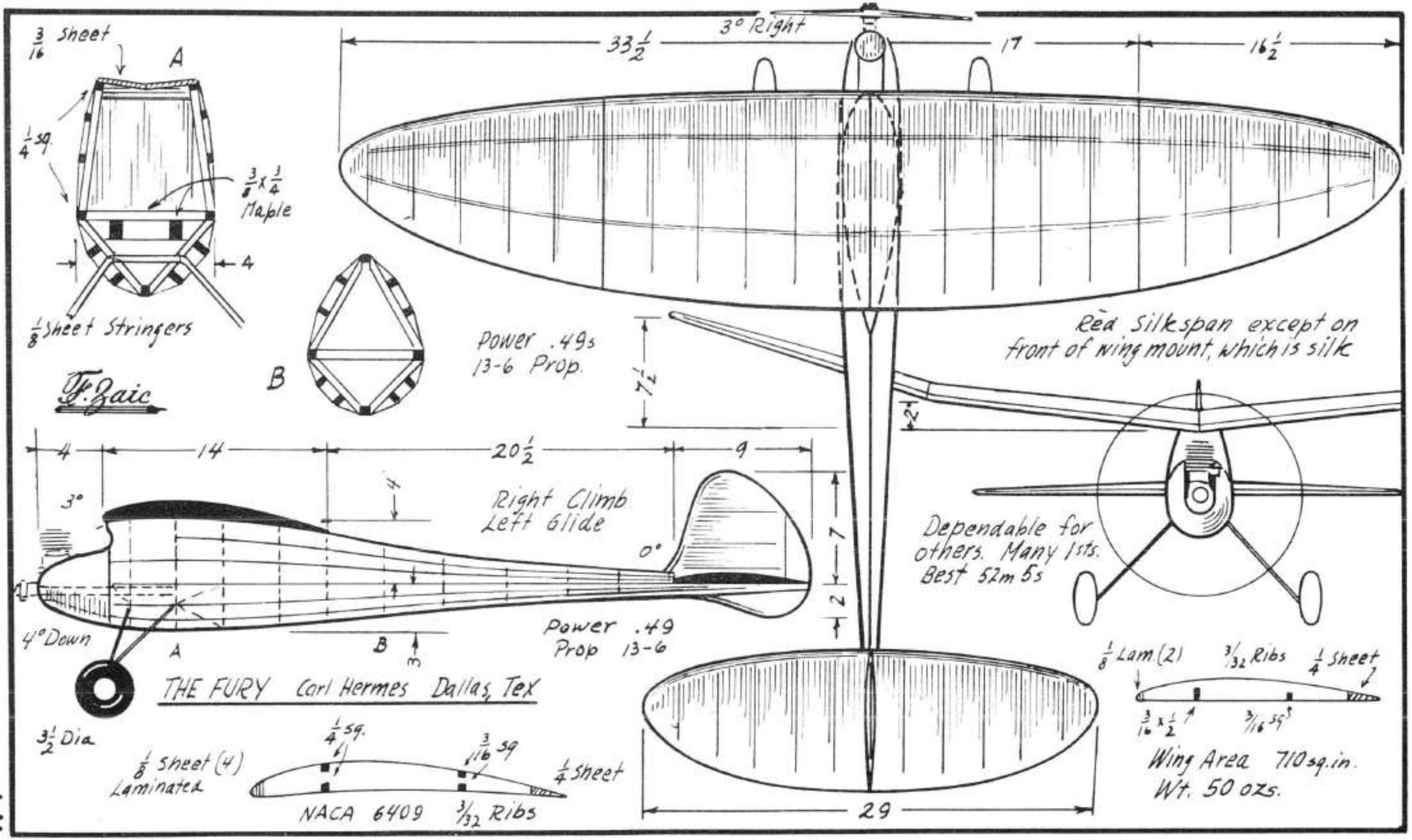

Walker's Pressure Tank
MacNabb Radio
McCoy .19
Front Rotary
Flying Weight 4 lbs.
60
4
3 1/2
3/8 Sheet Tips
3/8 Washout
5
10
16
8
3 1/2
1°
4 3/8
2 1/4
9 1/2
-1 1/2°
1 5/8 x 3 1/2 Rudder
Hatch on Left side
Lam 3/8 x 3/8
3/16 x 1/2
3/8 sq
1/4 Sheet
1/16 Sheet
1/8 sq.
3/8 x 1 1/4
1/2 x 5/8
1/4 x 3/4
1/8 Ribs
1/8 x 1/2
8
22
7° Down Thrust
Mac's ROBOT R/C
by Francis McElwee
Linden, N.J.
F. Zaic
Detailed in Sept. 1951 AIR TRAILS

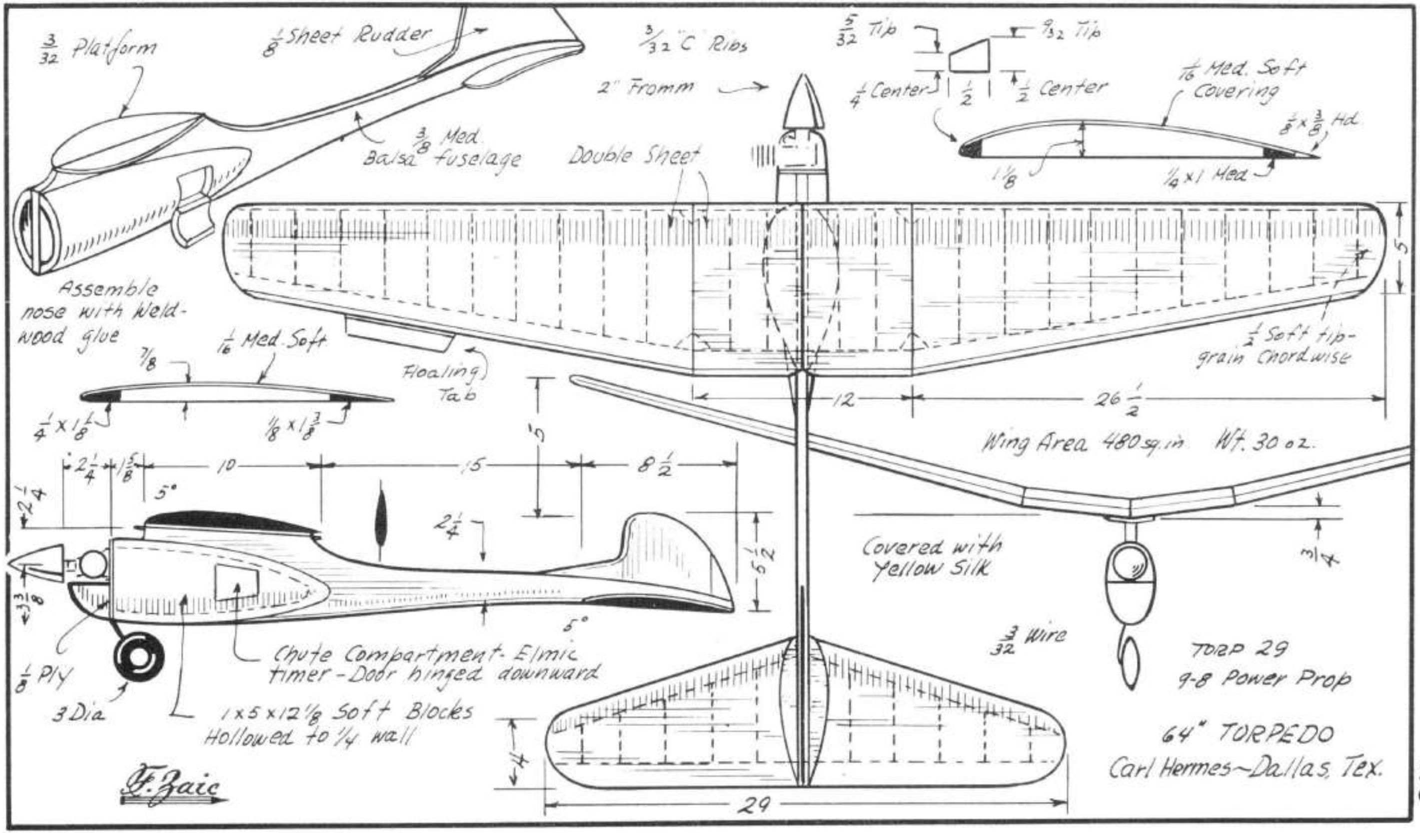

1/8 Sheet Bottom Crutch
8 1/4
12 3/4
2 1/4
8
Hatch outline
1/8 Sheet Sides
3
6
14
4 3/4
1 1/2
1/32 Sheet
5/32 x 5/8
1/4 sq.
1/8 x 1/4
1/16 x 3/16
23
RADIO: 52mc - Control Research - Two tube Conversion Rcv. Circuit
Radio Wt. 9 oz
Model Wt. 18 oz.
Total Wt. 27 oz
Hatch on left side only
Rudder
5/8 T.E.
2" Dihedral
5
1 1/2
1 3/4
Model flown for over a year through calm & rough weather, summer and winter.
Batt
Rcvr
Rly
Escapement
Torque tube
Rubber Winder Hook
1 3/4" Wheels for 2 wh. Gr.
1 1/2" for 3 wh. Gr.
.065 ROYAL SPITFIRE (Inverted)
7" Kaysun Plastic Prop
Wing Area 273 sq. in.
Stab Area 93 sq. in.
7
1/20 Sheet
3/32 sq.
3/16 x 3/4
5/16 sq.
1/8 x 3/8
1/8 x 1/4
19
4 3/4
46" SPAN R/C
by John Worth
Hampton Va.
F. Zaic

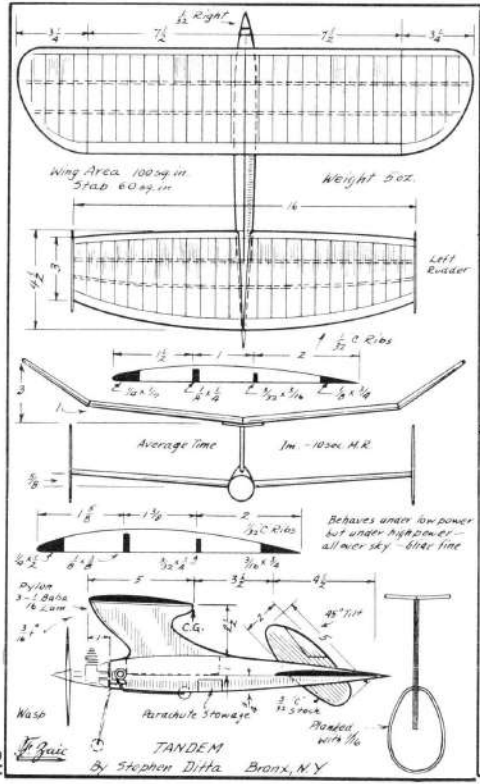

Full Size Plans 3/ AEROMODELLER
May, 1950 AEROMODELLER
Wt. 26 oz.
4" Dihedral at tips
E.D. Bee Engine
Dews Radio Unit
Queen Bee
by. P. GRIWADE England
48
8
3 1/2
3/16 sq
1/8 × 1/4
1/16 × 3/4
2 3/4
3°
4 1/4
15
6 1/4
7
0°
18
6
Batt
C.G.
Rcvr
Rly
Escapement
3/16 sq. Frame
10" Tread
1/8 × 3/16
1/8 × 3/4

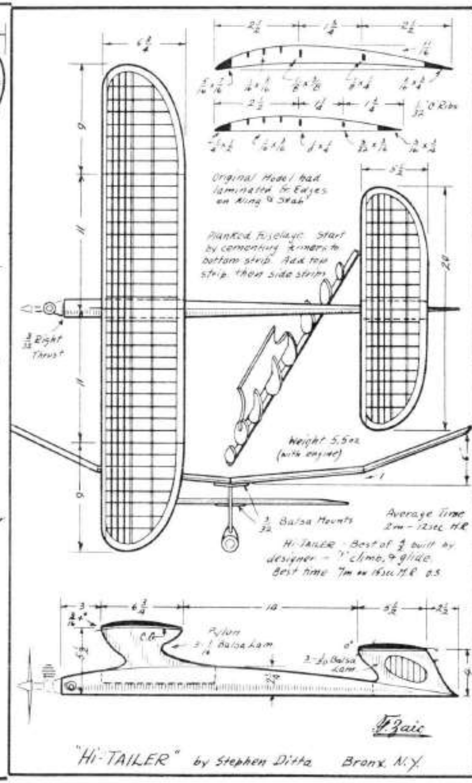

Wing NACA 6409
Stab 51 64009
300
665
965
199
Wing Area 37.1 dm²
Stab Area 11.8 dm²
48.9 dm²
Total Wt. 780gr.
100
100
80
199
750
150
1950 International Winner – Gas Model Meet – Paris
by Gerhard Schmid Baden Switzerland
150
870

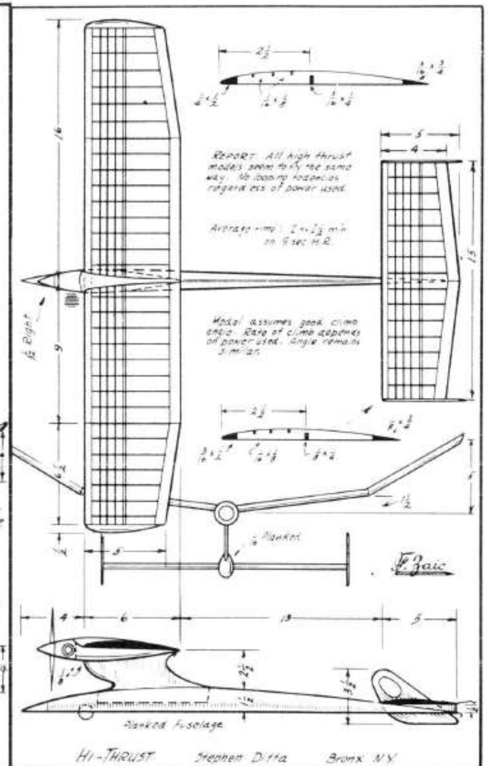

180
300
480
90
105
35
130
350
100
100
390
F. Zaic
Class D.1 0.75cm³ Engine
MILLIE
Hans P. Aasse Oslo, Norway

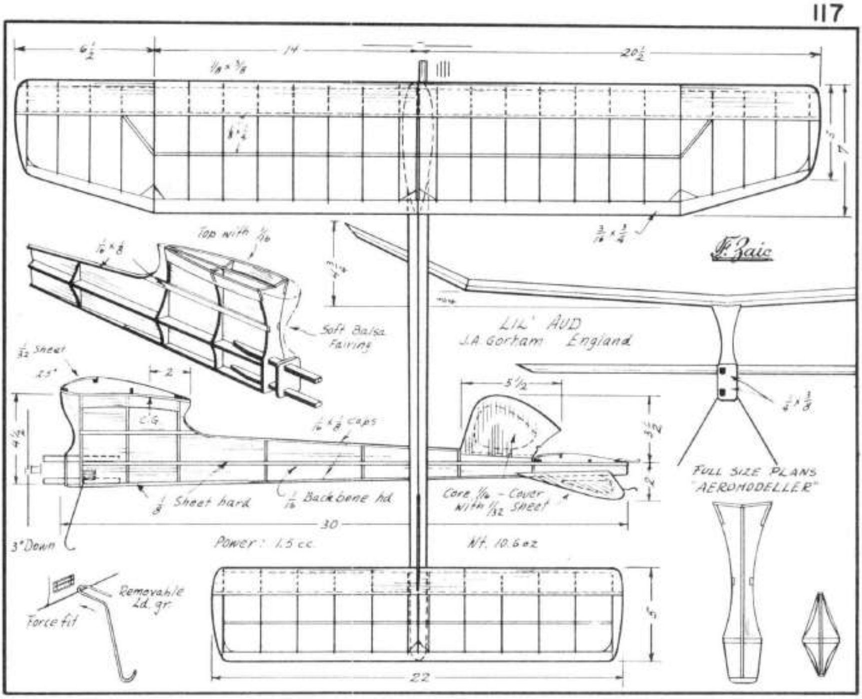

3/16 Sheet
A
1/4 sq.
3/8 x 3/4 Maple
4
1/8 Sheet Stringers
B
F. Zaic
3° Right
33 1/2
17
16 1/2
Power .49s
13-6 Prop.
7 1/2
2
Red Silkspan except on front of wing mount, which is silk
4
14
20 1/2
9
3°
Right Climb
Left Glide
0°
7
2
Dependable for others. Many 1sts. Best 52m 5s
4° Down
A
B
3
Power .49
Prop 13-6
THE FURY Carl Hermes Dallas, Tex
3 1/2 Dia
1/4 sq.
3/16 sq
1/8 Sheet (4) Laminated
1/4 Sheet
NACA 6409
3/32 Ribs
29
1/8 Lam. (2)
3/32 Ribs
1/4 Sheet
3/16 x 1/2
3/16 sq
Wing Area 710 sq.in.
Wt. 50 ozs.


3/32 Platform
1/8 Sheet Rudder
3/8 Med. Balsa fuselage
3/32 "C" Ribs
2" Fromm
5/32 Tip
9/32 Tip
1/4 Center
1/2
1/2 Center
1/16 Med. Soft Covering
1/8 x 3/8 Hd.
1 1/8
1/4 x 1 Med.
Double Sheet
Assemble nose with Weld-wood glue
7/8
1/16 Med. Soft
1/4 x 1 1/8
1/8 x 1 3/8
Floating Tab
5
1/2 Soft tip-grain Chordwise
12
26 1/2
Wing Area 480 sq. in. Wt. 30 oz.
2 1/4
1 5/8
10
15
8 1/2
5°
2 1/4
2 1/4
5 1/2
3 3/8
5°
Covered with Yellow Silk
3/4
3/32 Wire
Chute Compartment-Elmic timer-Door hinged downward
1/8 Ply
3 Dia
1 x 5 x 12 1/8 Soft Blocks Hollowed to 1/4 wall
4
29
TORP 29
9-8 Power Prop
64" TORPEDO
Carl Hermes~Dallas, Tex.
F. Zaic


Wing Area 100 sq. in.
Stab 60 sq. in.
Weight 5 oz.
Left Rudder
Average Time 1m. - 10sec. H.R.
Behaves under low power but under high power — all over sky — Glide fine
Pylon 3 - 1 Balsa Lam
C.G.
45° Tilt
Wasp
Parachute Stowage
Planked with 1/16
TANDEM
By Stephen Ditta Bronx, N.Y.


Original Model had laminated Edges on Wing & Stab
Planked Fuselage. Start by cementing formers to bottom strip. Add top strip, then side strips
Right Thrust
Weight 5.5 oz (with engine)
Balsa Mounts
Average Time 2m - 12sec. H.R.
Hi-TAILER - Best of built by designer - climb, & glide.
Best time 7m on 15sec. H.R.
Pylon Balsa Lam
C.G.
Balsa Lam
"HI-TAILER" by Stephen Ditta Bronx, N.Y.

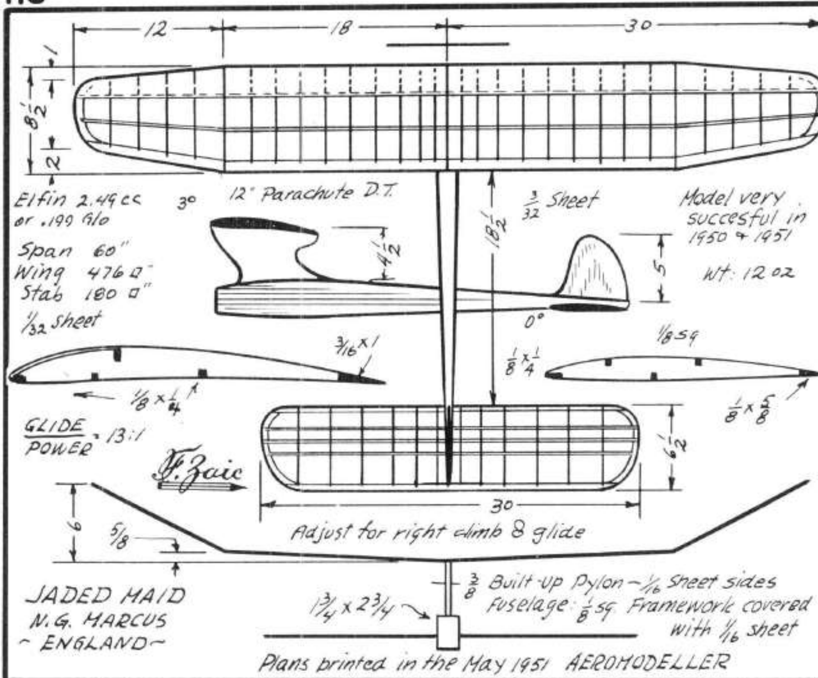

REPORT: All high thrust models seem to fly the same way. No looping tendencies regardless of power used.
Average time 2 - 2½ min on 9 sec H.R.
Model assumes good climb angle. Rate of climb depends on power used. Angle remains similar.
Right
Planked
Planked Fuselage
HI-THRUST Stephen Ditta Bronx N.Y.

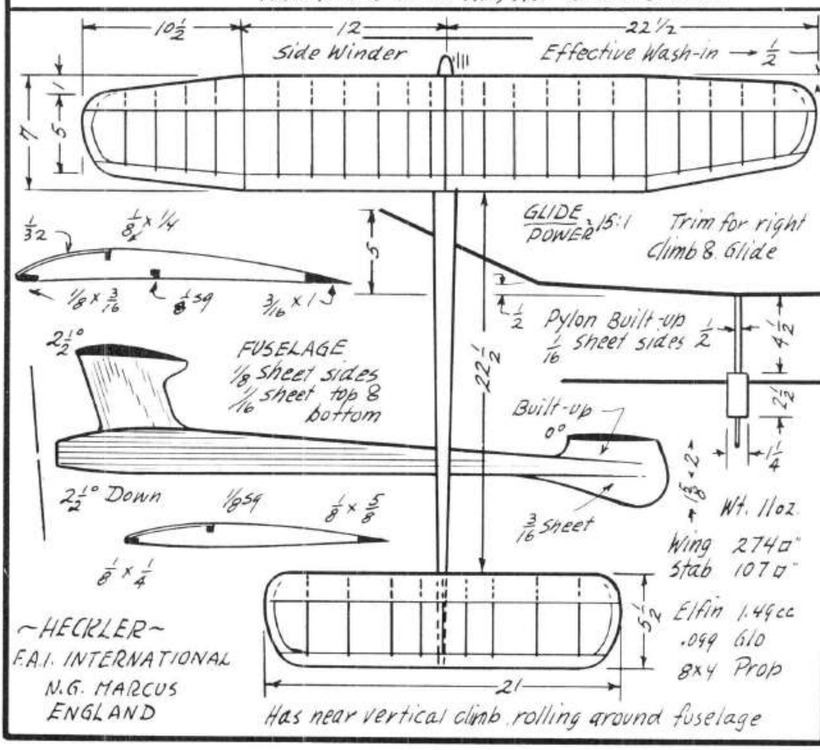


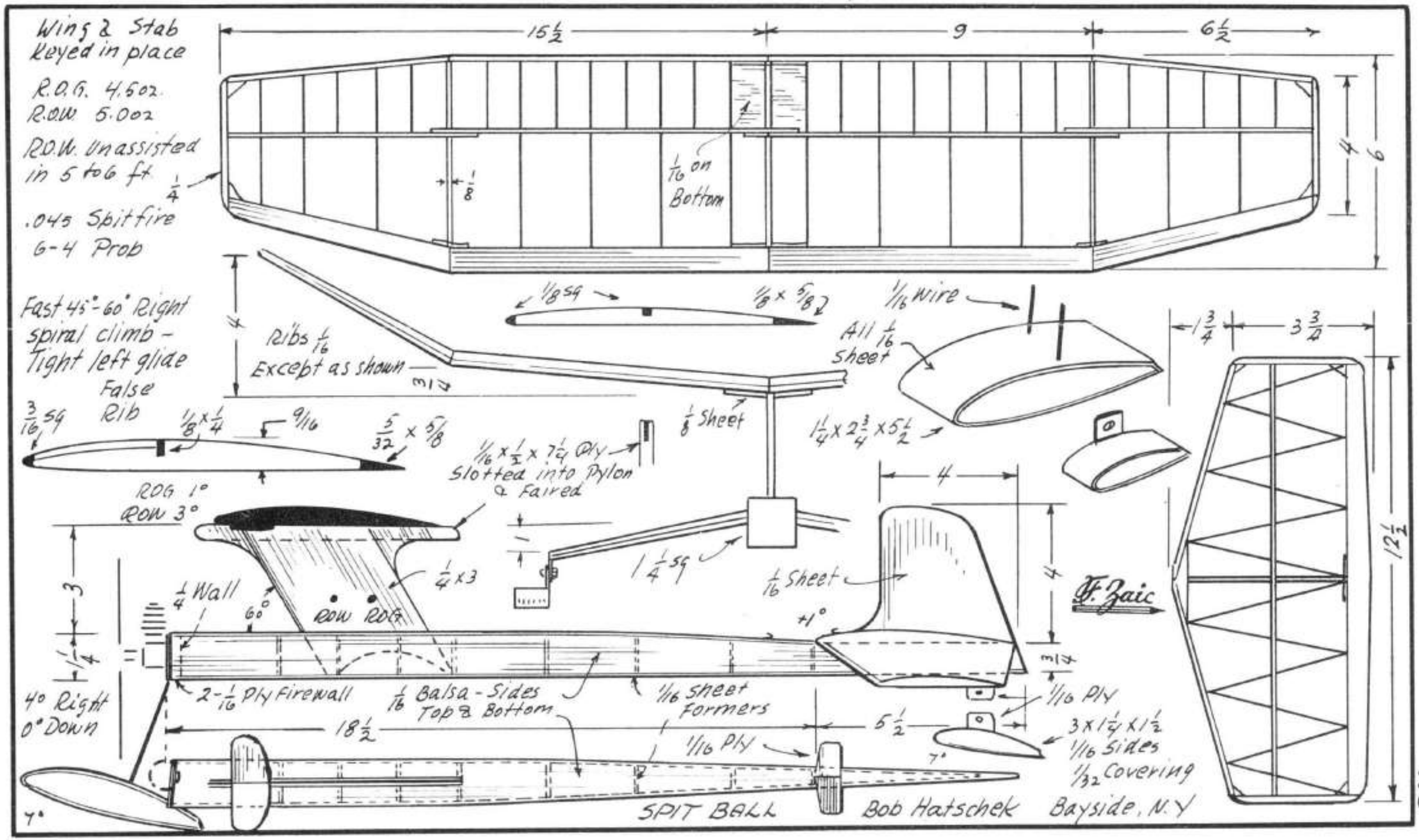
J.A.GORHAM---Your remarks on high power are interesting. My theory and method of trimming has always been to design as long a moment arm as possible with about 40% tail, and rig for correct glide with C.G. at about 60% from L.E. The procedure then is to try the model with maximum power and short run, and then watch the tendency. If, as it surely will, it attempts to loop, then the C.G. is moved back about 1/8" by adding ballast at rear, and the tail incidence is increased to give correct glide. These adjustments are repeated until the model on a straight trim just holds its own in a vertical climb.

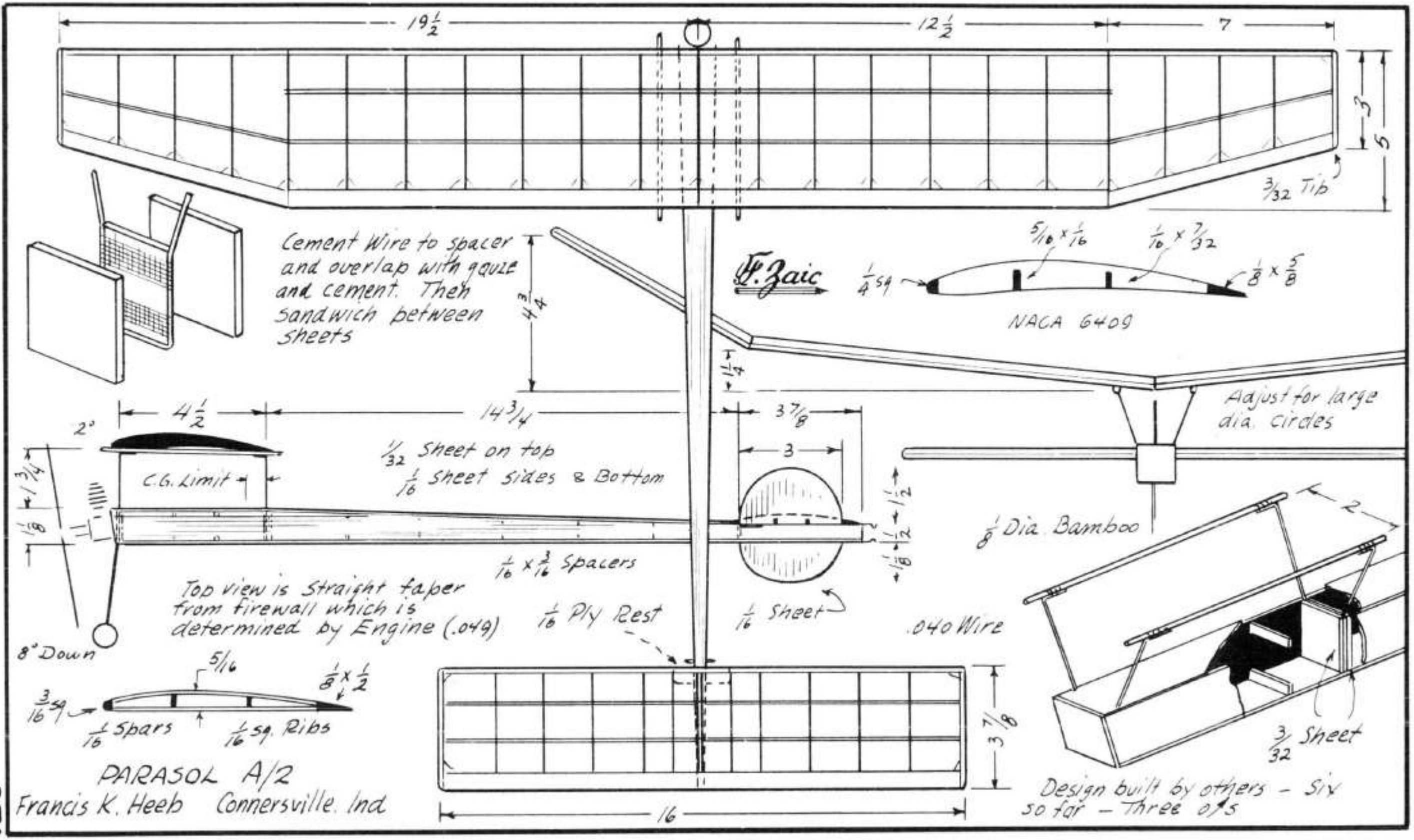
The angles of incidence between wing and tail are now so close as to make one suspect its longitudinal stability. If this does show up (failure to pull out of a dive after a stall off power) then downthrust is added and the above adjustments reversed slowly until a point is reached where the climb is straight or slightly turning, and the pull-out is clean. At no time do I use a spiral climb.

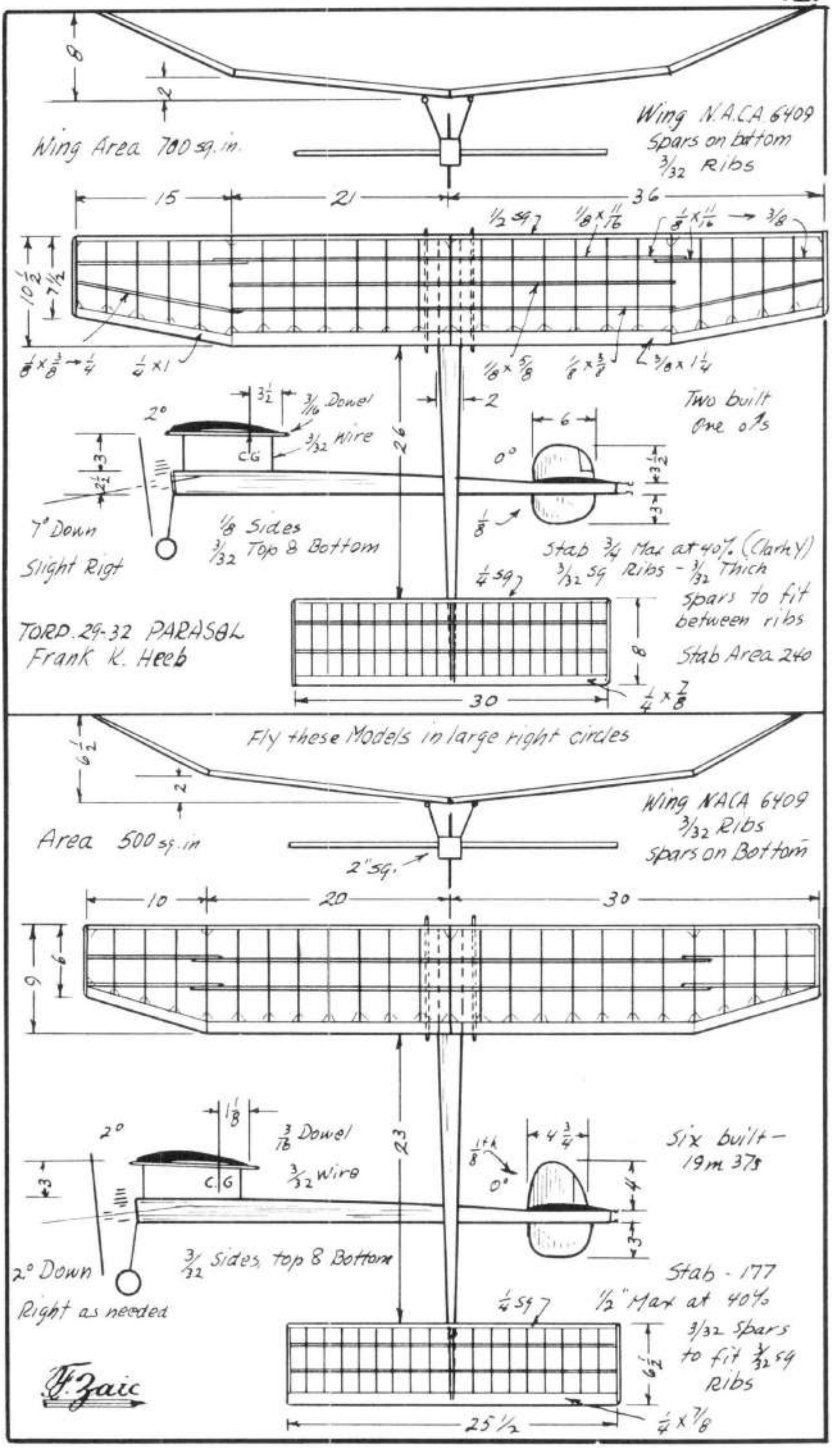
My limited time at present is spent on Wakefields. You may have read that I had a fairly successful model last season, the " GHOST" with 12 strands of 1/4 x 1/20, and a 2m 15sec motor run. It's average throughout the whole season was just under 4 minutes.----Experimenting is concentrated on torque and dynamometer tests on rubber motors. So far I have reached several interesting conclusions. 1st--That better power characteristics have shown up on a 70" motor operating between 28" hooks than the same motor operating between 50" hooks. Theory being that the power stored goes not into stretching of the motor but into torque where there is less tension. Also friction at bearing is less. Another conclusion is that rapid winding promotes a better power run (more mechanical efficiency).

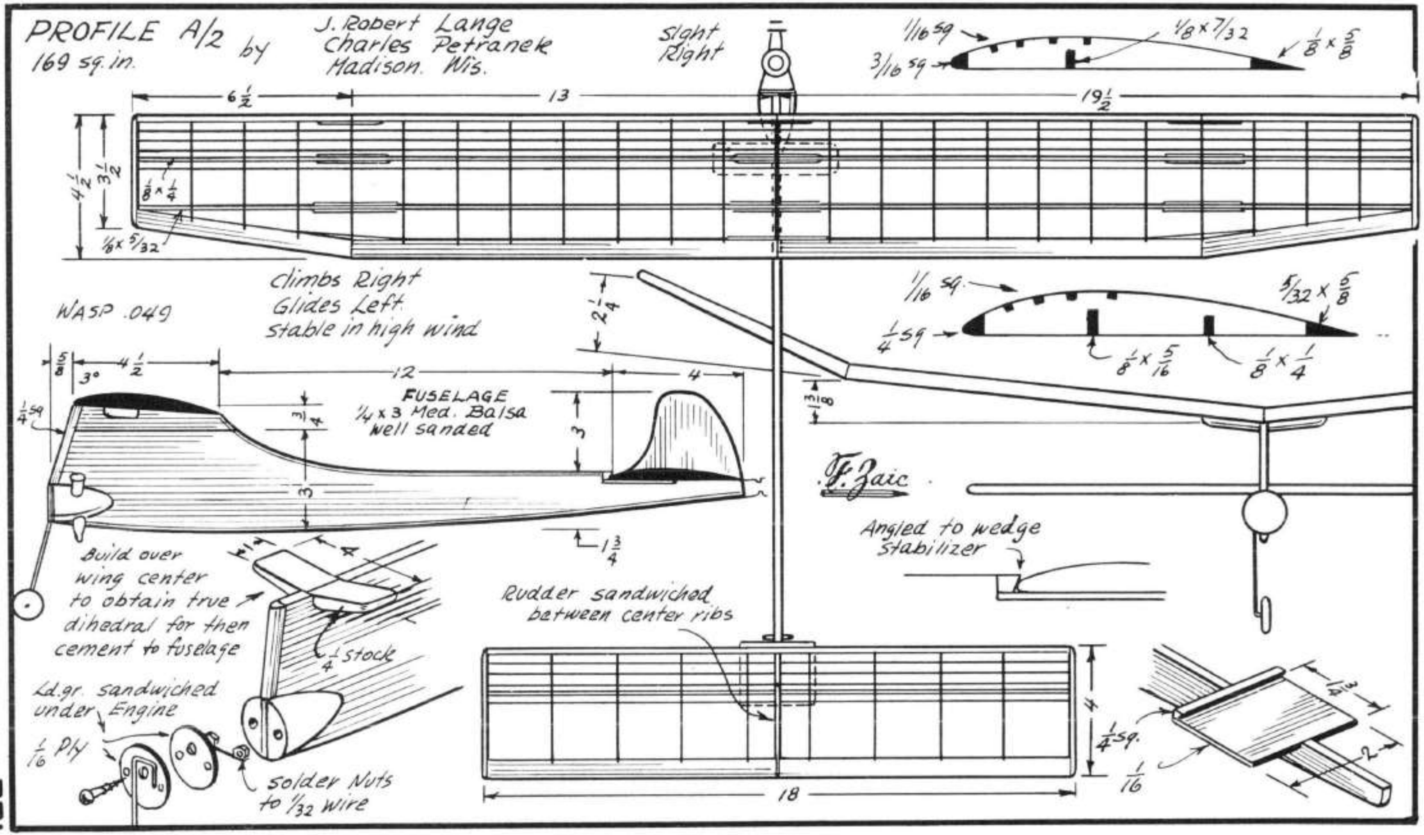

12
18
30
8 1/2
1
2
Elfin 2.49 cc
or .199 Glo
3°
12" Parachute D.T.
3/32 Sheet
Model very succesful in 1950 & 1951
4 1/2
18 1/2
5
Span 60"
Wing 476 □"
Stab 180 □"
Wt. 12 oz
1/32 Sheet
0°
3/16 x 1
1/8 sq
1/8 x 1/4
1/8 x 1/4
1/8 x 5/8
GLIDE/POWER = 13:1
F. Zaic
6 1/2
6
5/8
30
Adjust for right climb & glide
3/8 Built-up Pylon – 1/16 Sheet sides
Fuselage: 1/8 sq. Framework covered with 1/16 sheet
1 3/4 x 2 3/4
JADED MAID
N.G. MARCUS
~ ENGLAND ~
Plans printed in the May 1951 AEROMODELLER

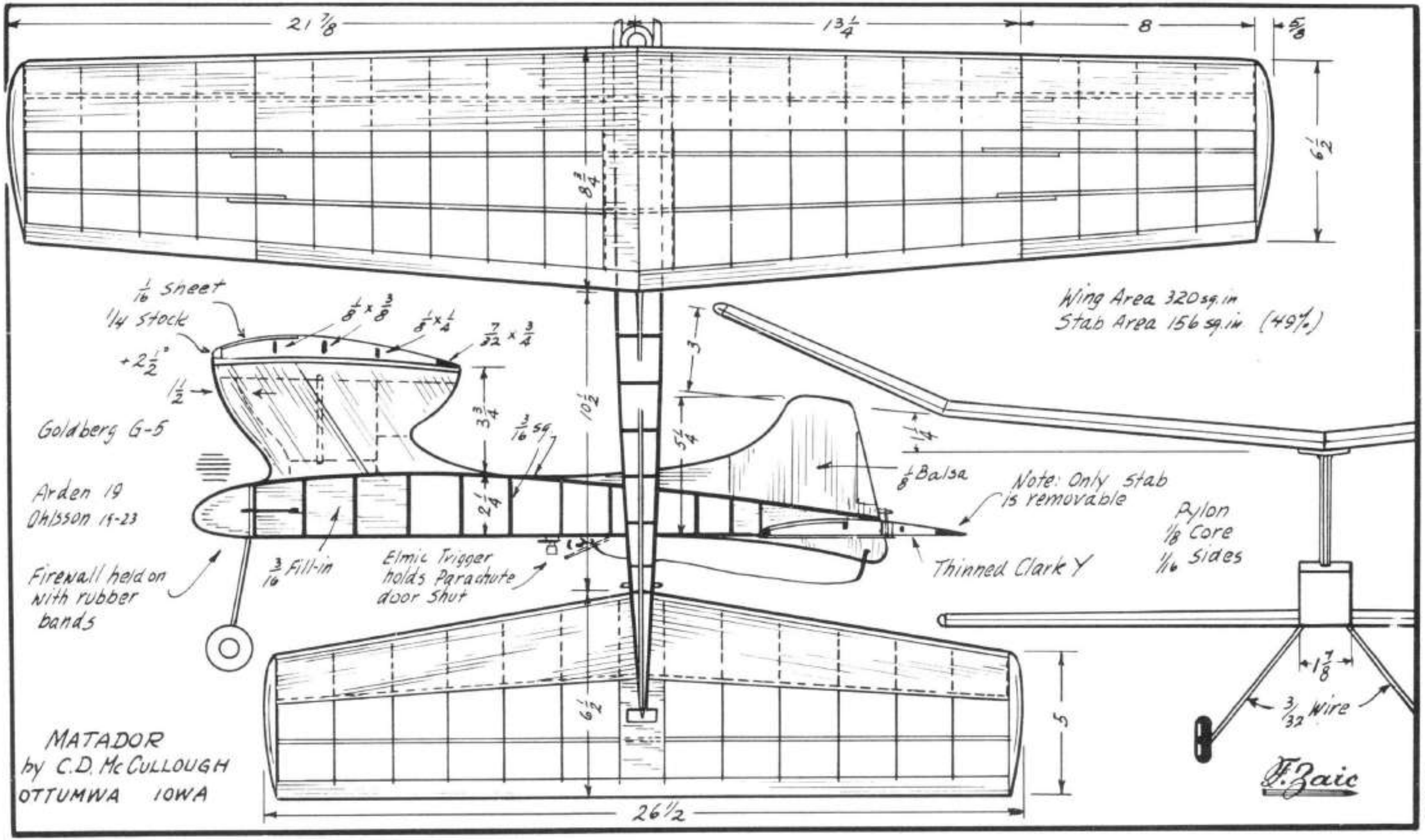

10 1/2
12
22 1/2
Side Winder
Effective Wash-in → 1/2
7
1
5
1/32
1/8 x 1/4
5
GLIDE/POWER = 15:1
Trim for right Climb & Glide
1/8 x 3/16
1/8 sq
3/16 x 1
1/2
Pylon Built-up 1/16 sheet sides
1/2
4 1/2
2 1/2°
FUSELAGE
1/8 sheet sides
1/16 sheet top & bottom
22 1/2
Built-up
0°
2 1/2
1 1/4
1 5/8
2
2 1/2° Down
1/8 sq
1/8 x 5/8
3/16 Sheet
Wt. 11 oz.
1/8 x 1/4
Wing 274 □"
Stab 107 □"
5 1/2
Elfin 1.49cc
.099 Glo
8x4 Prop
~HECKLER~
F.A.I. INTERNATIONAL
N.G. MARCUS
ENGLAND
21
Has near vertical climb, rolling around fuselage

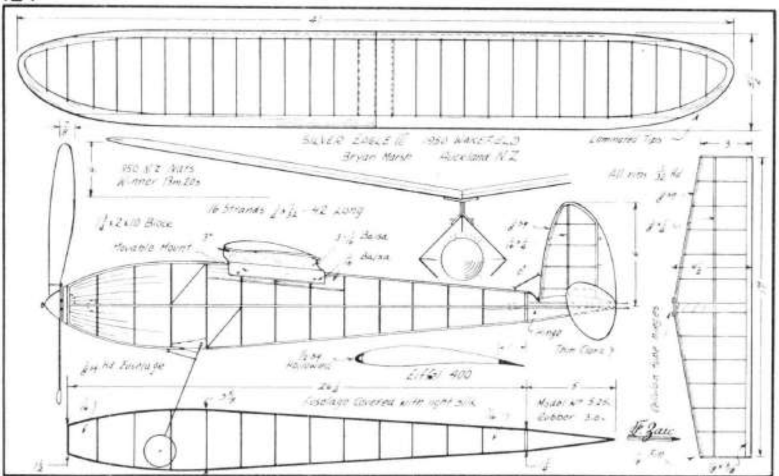

Wing & Stab
Keyed in place
R.O.G. 4.5oz.
R.O.W. 5.0oz
R.O.W. Unassisted
in 5 to 6 ft
.045 Spitfire
6-4 Prop
Fast 45°-60° Right
spiral climb -
Tight left glide
False
Rib
Ribs 1/16
Except as shown
1/16 on
Bottom
1/8 Sq
1/8 x 5/8
1/16 Wire
All 1/16
Sheet
1 1/4 x 2 3/4 x 5 1/2
3/16 Sq
1/8 x 1/4
9/16
5/32 x 5/8
1/8 Sheet
1/16 x 1/2 x 7 1/4 Ply
Slotted into Pylon
& Faired
ROG 1°
ROW 3°
1/4 x 3
1 1/4 Sq
1/16 Sheet
1/4 Wall
60°
ROW ROG
+1°
F. Zaic
4° Right
0° Down
2-1/16 Ply Firewall
1/16 Balsa - Sides
Top & Bottom
1/16 Sheet
Formers
1/16 Ply
3 x 1 1/4 x 1 1/2
1/16 Sides
1/32 Covering
1/16 Ply
SPIT BALL
Bob Hatschek
Bayside, N.Y.

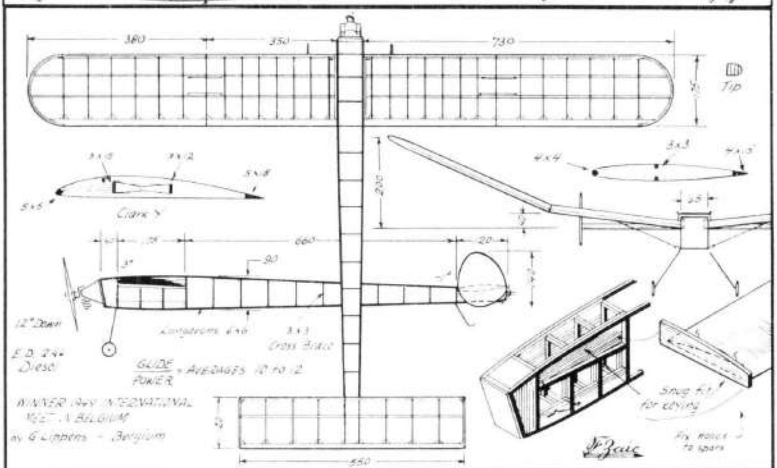

19 1/2
12 1/2
7
3
5
3/32 Tip
Cement Wire to spacer and overlap with gauze and cement. Then sandwich between sheets
4 3/4
F. Zaic
5/16 x 1/16
1/16 x 7/32
1/4 sq
1/8 x 5/8
NACA 6409
1 1/4
Adjust for large dia. Circles
4 1/2
14 3/4
3 7/8
3
2°
1 3/4
C.G. Limit
1/32 Sheet on top
1/16 Sheet sides & Bottom
1 1/2
1 1/8
1/2
1/8
1/8 Dia. Bamboo
2
1/16 x 3/16 Spacers
Top view is Straight taper from firewall which is determined by Engine (.049)
1/16 Ply Rest
1/16 Sheet
.040 Wire
8° Down
5/16
1/8 x 1/2
3/16 sq
1/16 Spars
1/16 sq. Ribs
3 7/8
3/32 Sheet
PARASOL A/2
Francis K. Heeb Connersville, Ind
16
Design built by others - Six so far - Three o/s

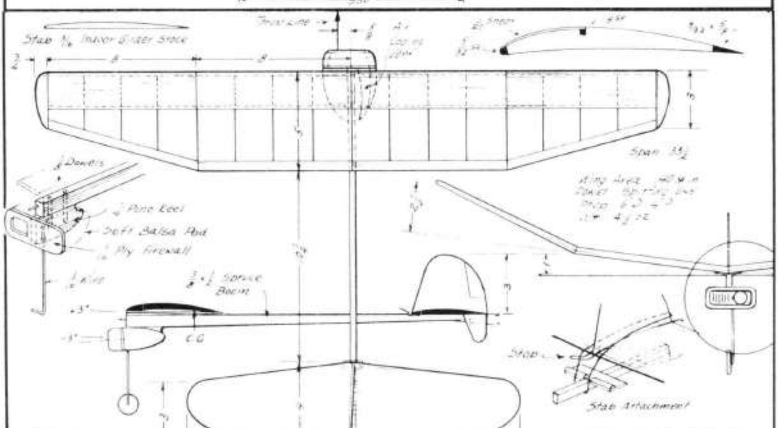

Wing Area 700 sq. in.
Wing N.A.C.A 6409
Spars on bottom
3/32 Ribs
15
21
36
1/2 sq.
1/8 x 11/16
1/8 x 11/16 → 3/8
10 1/2
7 1/2
1/8 x 3/8 → 1/4
1/4 x 1
1/8 x 5/8
1/8 x 3/8
3/8 x 1 1/4
2°
3 1/2
3/16 Dowel
3/32 Wire
C.G
26
2
Two built
One o/s
6
0°
3 1/2
3
7° Down
Slight Rigt
1/8 Sides
3/32 Top & Bottom
1/8
Stab 3/4 Max at 40% (Clark Y)
3/32 sq. Ribs - 3/32 Thick
spars to fit between ribs
1/4 sq.
TORP. 29-32 PARASOL
Frank K. Heeb
8
Stab Area 240
30
1/4 x 7/8
Fly these Models in large right circles
6 1/2
2
Wing NACA 6409
3/32 Ribs
Spars on Bottom
Area 500 sq. in
2" sq.
10
20
30
9
6
2°
1 1/8
3/16 Dowel
3/32 Wire
C.G
23
4 3/4
Six built -
19m 37s
0°
4
3
2° Down
Right as needed
3/32 Sides, top & Bottom
Stab - 177
1/2" Max at 40%
1/4 sq.
3/32 Spars
to fit 3/32 sq.
Ribs
6 1/2
F. Zaic
25 1/2
1/4 x 7/8

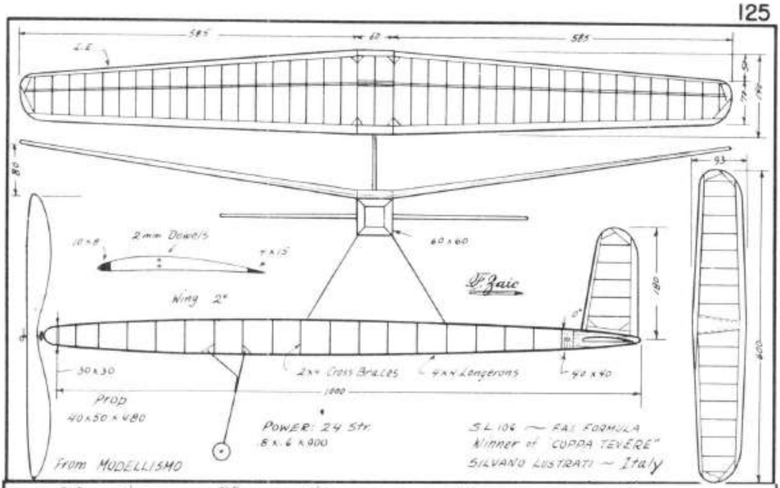

PROFILE A/2
169 sq. in.
by J. Robert Lange
Charles Petranek
Madison. Wis.
Slight Right
1/16 sq
3/16 sq
1/8 x 7/32
1/8 x 5/8
6 1/2
13
19 1/2
4 1/2
3 1/2
1/8 x 1/4
1/8 x 5/32
Climbs Right
Glides Left
stable in high wind
WASP .049
2 1/4
1/16 sq.
1/4 sq
5/32 x 5/8
1/8 x 5/16
1/8 x 1/4
5/8
3°
4 1/2
12
4
1/4 sq
FUSELAGE
1/4 x 3 Med. Balsa
well sanded
3/4
3
1 3/8
F. Zaic
1 3/4
Angled to wedge stabilizer
Build over wing center to obtain true dihedral for then cement to fuselage
1/4 stock
Rudder sandwiched between center ribs
Ld. gr. sandwiched under Engine
1/16 Ply
Solder Nuts to 1/32 wire
18
1/4 sq.
1/16
2


21 7/8
13 1/4
8
5/8
6 1/2
8 3/4
1/16 sheet
1/4 stock
1/8 x 3/8
1/8 x 1/4
7/32 x 3/4
+2 1/2°
1/2
3 3/4
3/16 sq.
10 1/2
3
5 1/4
1 1/4
Goldberg G-5
2 1/4
1/8 Balsa
Wing Area 320 sq. in
Stab Area 156 sq. in (49%)
Note: Only Stab is removable
Arden 19
Ohlsson 19-23
Pylon
1/8 Core
1/16 Sides
3/16 Fill-in
Elmic Trigger holds Parachute door Shut
Thinned Clark Y
Firewall held on with rubber bands
6 1/2
5
1 7/8
3/32 Wire
MATADOR
by C.D. McCULLOUGH
OTTUMWA IOWA
26 1/2
F. Zaic

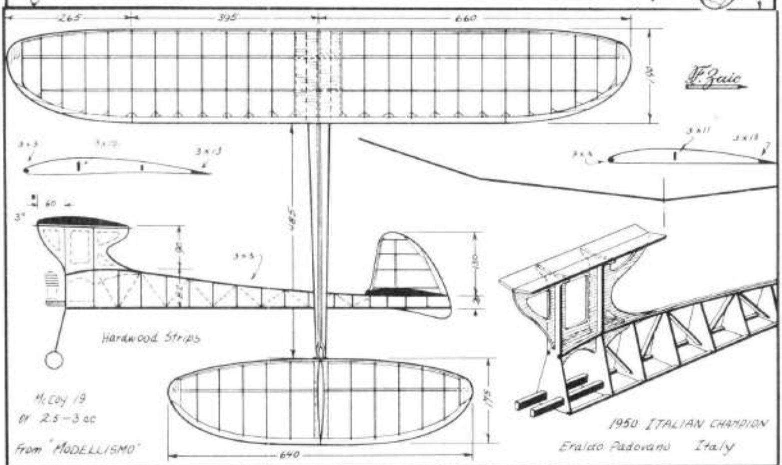

SILVER EAGLE III 1950 WAKEFIELD
Bryan Marsh Auckland N.Z.
1950 N.Z. Nats
Winner 13m.20s
16 Strands 1/4 x 1/32 - 42 Long
Laminated Tips
Movable Mount
Eiffel 400
Fuselage Covered with light silk
Hinge
F. Zaic


380
350
730
Tip
Clark Y
660
12° Down
E.D. 2cc
Diesel
GLIDE / POWER = AVERAGES 10 to 12
Longerons 6x6
Cross Brace
WINNER 1949 INTERNATIONAL
MEET IN BELGIUM
by G. Lippens - Belgium
Snug fit for keying
550
F. Zaic

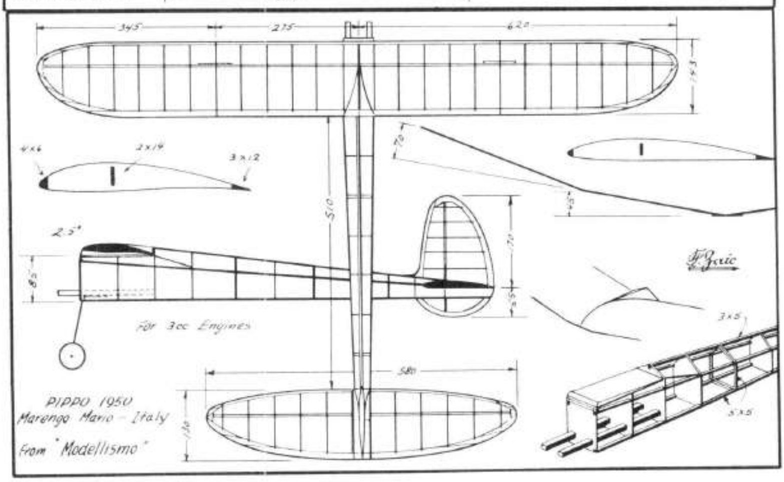

Thrust Line
Stab 1/16 Indoor Glider Stock
Dowels
Soft Balsa Pad
Ply Firewall
Spruce Boom
C.G.
Span 33 1/2
Stop
Stab Attachment
18
ASYMETRICAL THRUST
John Kiener Van Nuys, Calif.
F. Zaic



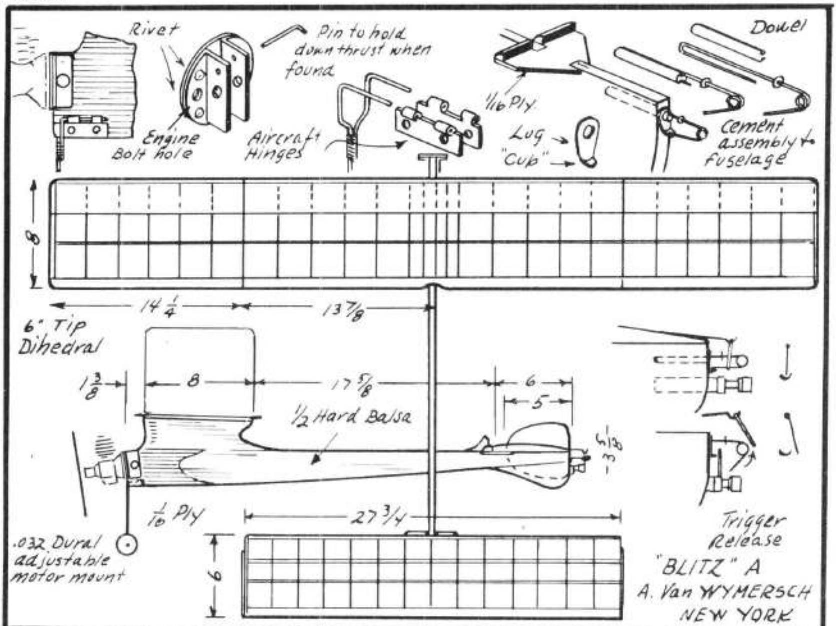
L.E.
585
60
585
80
93
10×8
2mm Dowels
4×15
60×60
Wing 2°
180
600
30×30
2×4 Cross Braces
4×4 Longerons
40×40
1000
Prop
40×50×480
POWER: 24 Str.
.8×.6×900
SL 106 — FAI FORMULA
Winner of "COPPA TEVERE"
SILVANO LUSTRATI — Italy
From MODELLISMO

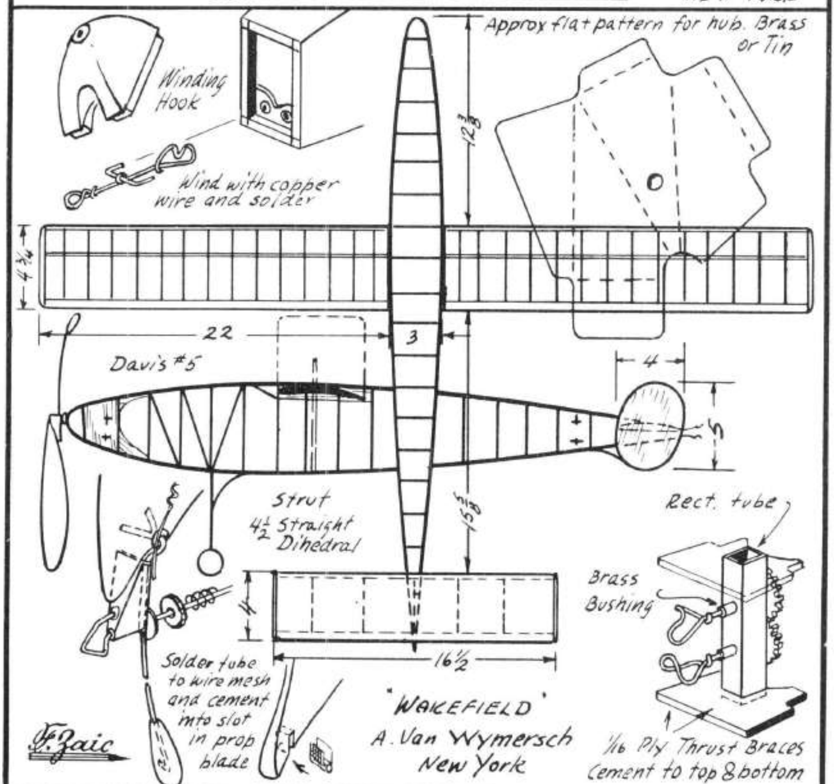


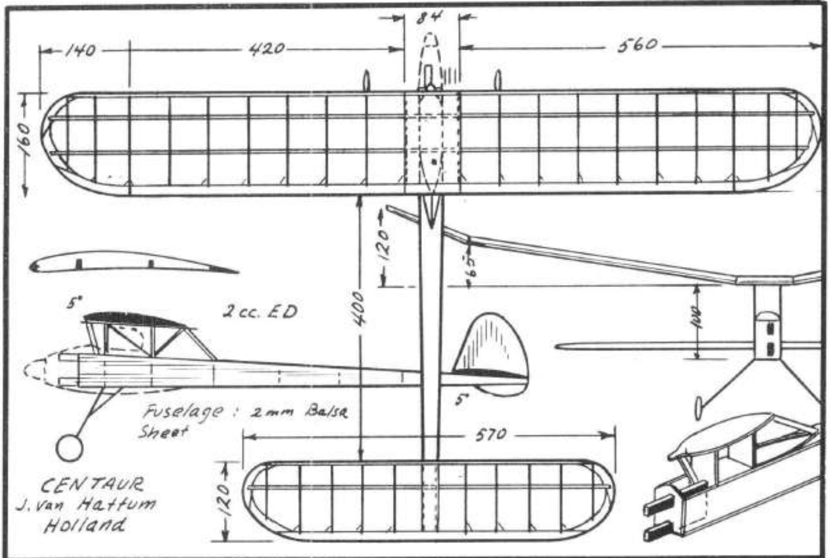
265
395
660
3×11
3×13
3×13
60
3°
485
3×3
130
Hardwood Strips
175
McCoy 19
or 2.5–3 cc
From "MODELLISMO"
640
1950 ITALIAN CHAMPION
Eraldo Padovano Italy

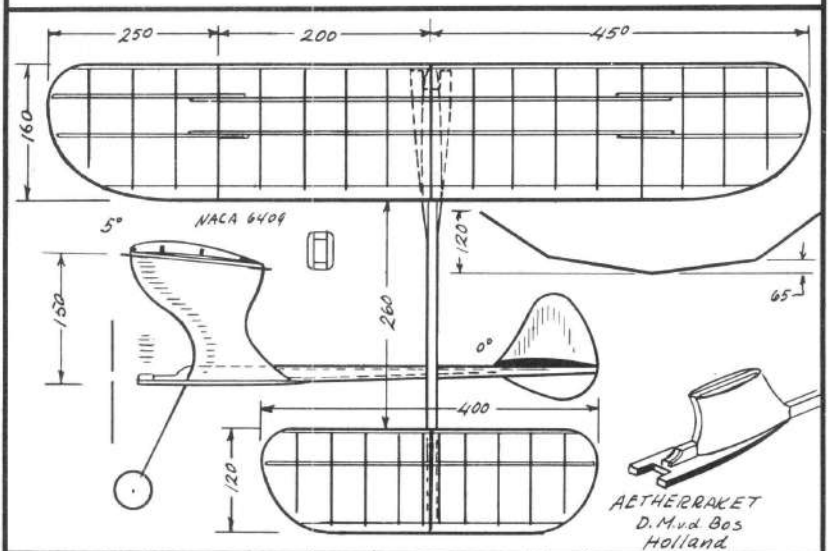


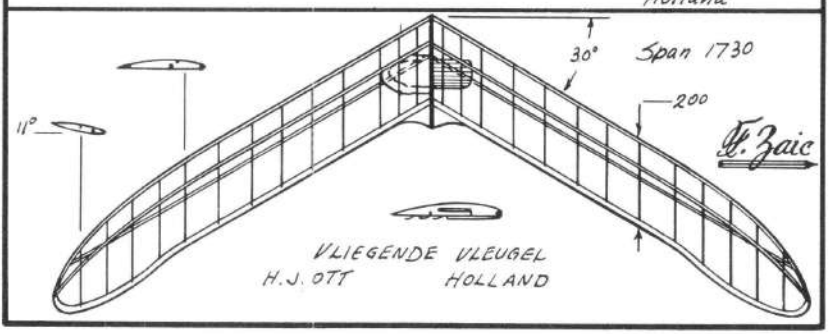
345
275
620
4×6
2×14
3×12
510
2.5°
85
For 3cc Engines
3×5
580
5×5
PIPPO 1950
Marengo Mario - Italy
From "Modellismo"

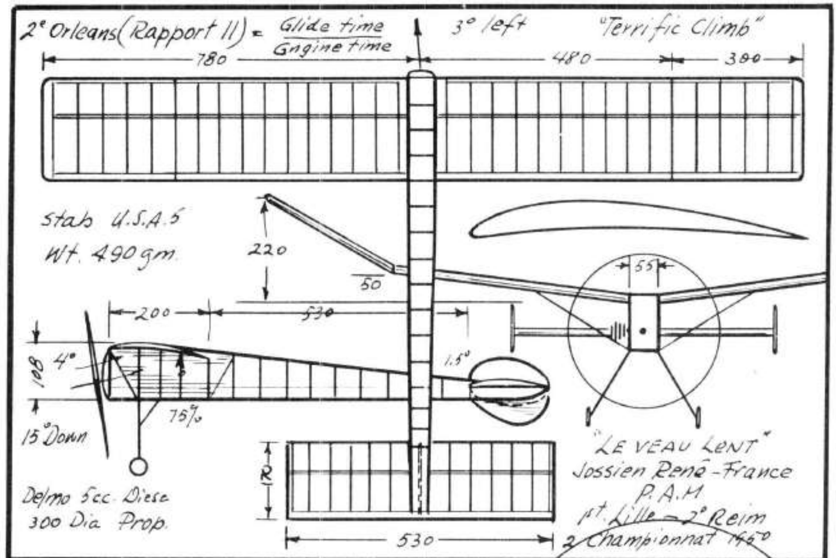

Rivet
Pin to hold down thrust when found
Dowel
1/16 Ply
Engine Bolt hole
Aircraft Hinges
Lug
"Cup"
Cement assembly to fuselage
8
14 1/4
13 7/8
6" Tip Dihedral
1 3/8
8
17 5/8
6
5
1/2 Hard Balsa
6 1/2
3
1/16 Ply
27 3/4
.032 Dural adjustable motor mount
6
Trigger Release
"BLITZ" A
A. Van WYMERSCH
NEW YORK

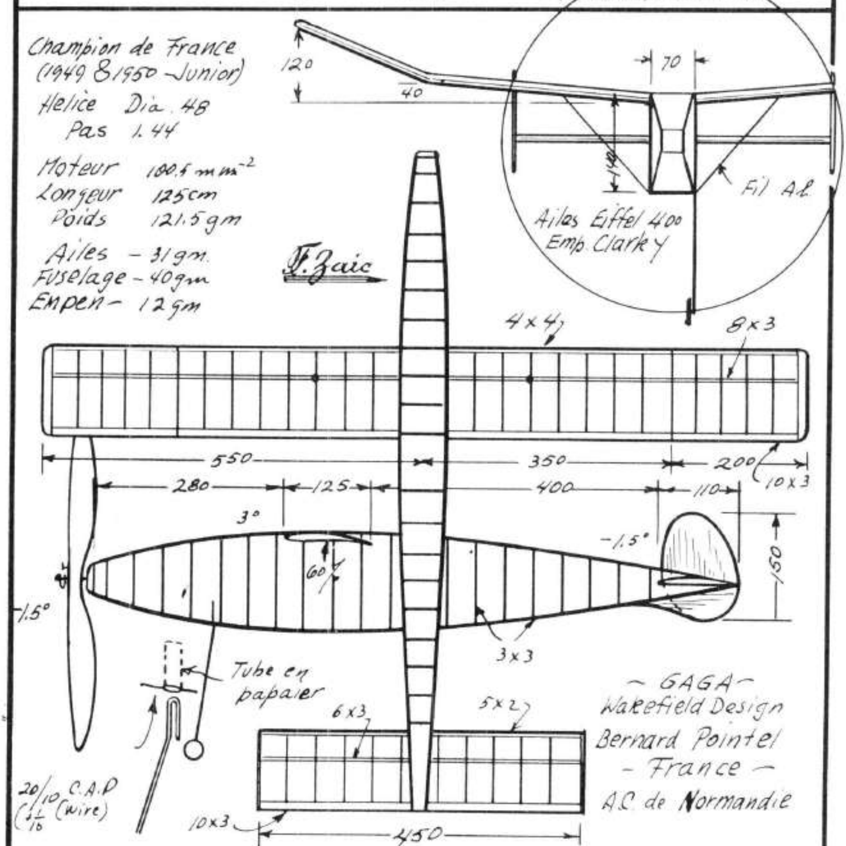

Approx flat pattern for hub. Brass or Tin
Winding Hook
Wind with copper wire and solder
12 3/8
4 3/4
22
3
Davis #5
4
5
Strut
4 1/2 Straight Dihedral
15 5/8
Rect. tube
Brass Bushing
4
16 1/2
Solder tube to wire mesh and cement into slot in prop blade
"WAKEFIELD"
A. Van Wymersch
New York
1/16 Ply Thrust Braces
Cement to top & bottom
F. Zaic

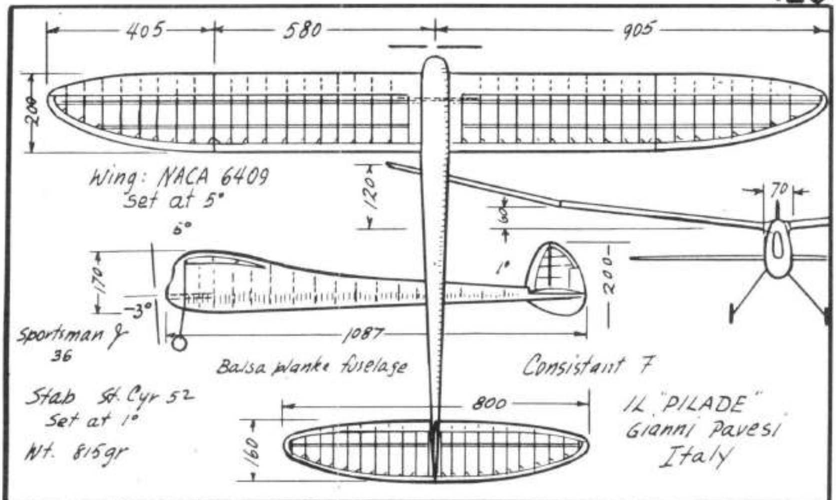

84
140
420
560
160
120
65
400
100
5°
2 cc. ED
5°
Fuselage : 2 mm Balsa Sheet
570
120
CENTAUR
J. van Hattum
Holland

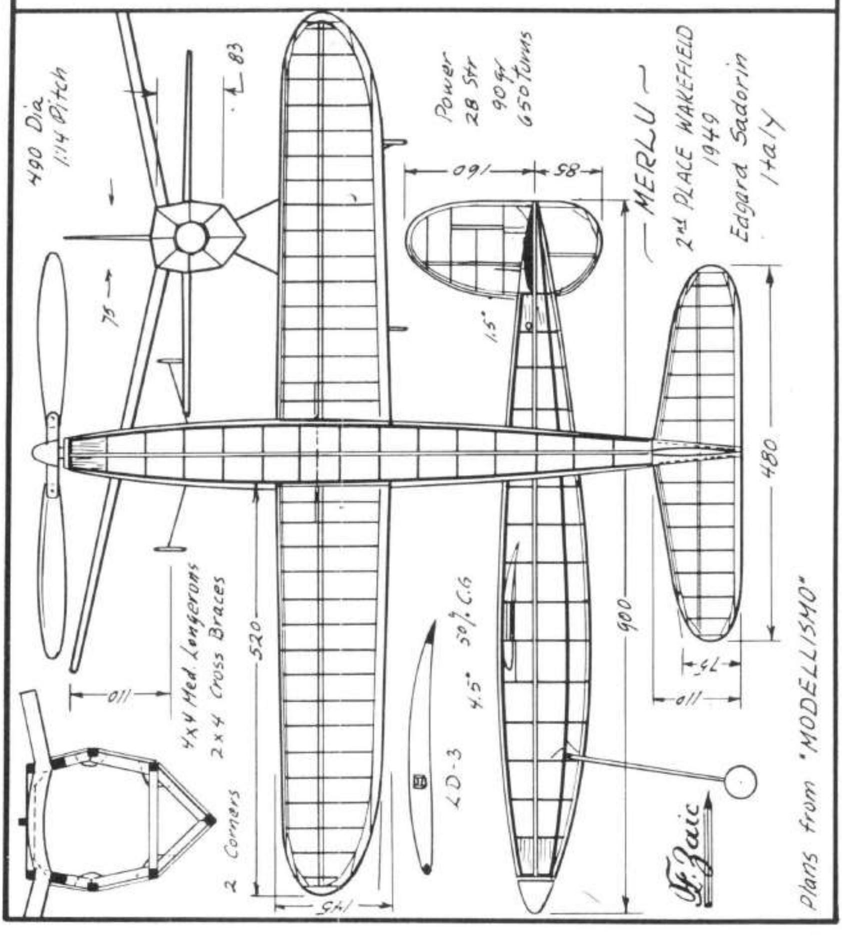

250
200
450
160
5°
NACA 6409
120
150
260
65
0°
400
120
AETHERRAKET
D. M. v. d. Bos
Holland

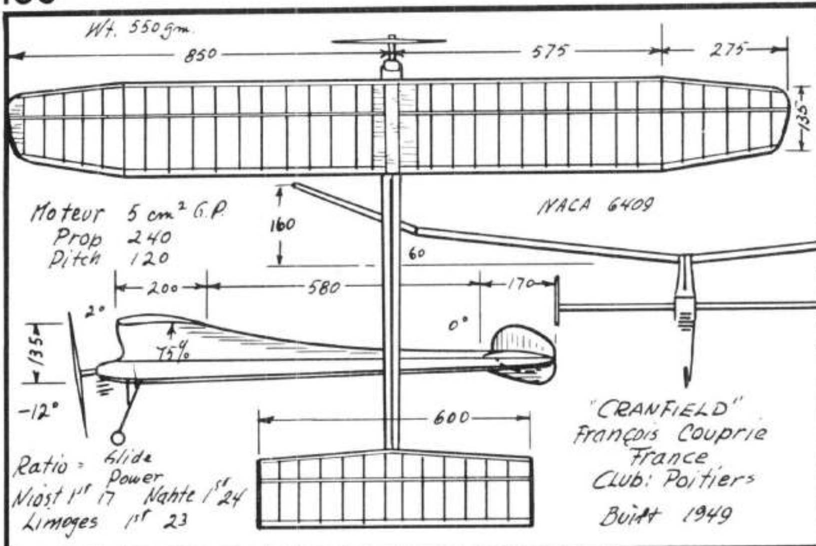

30°
Span 1730
200
11°
VLIEGENDE VLEUGEL
H. J. OTT
HOLLAND
F. Zaic

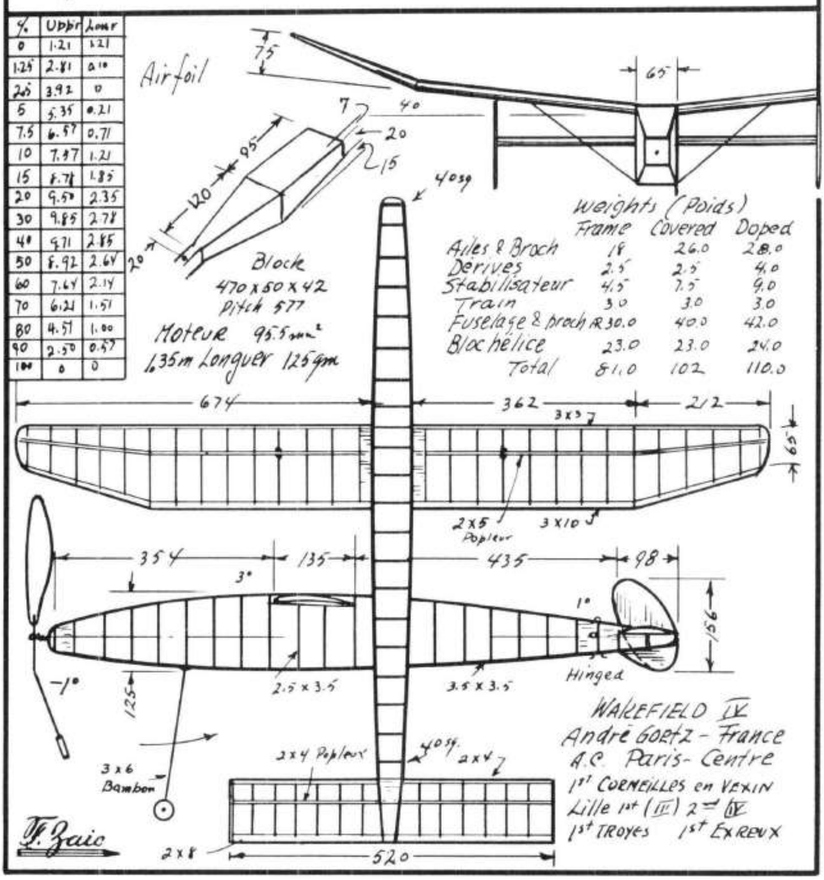

2e Orleans (Rapport II) = Glide time / Gngine time
3° left
"Terrific Climb"
780
480
300
Stab U.S.A. 5
Wt. 490 gm.
220
50
200
530
108
4°
1.5°
75%
15° Down
R
Delmo 5cc. Diese
300 Dia. Prop.
530
55
"LE VEAU LENT"
Jossien René - France
P.A.M.
1er Lille - 2e Reim
2 Championnat 1950


Champion de France
(1949 & 1950 - Junior)
Helice Dia. 48
Pas 1.44
Moteur 100.5 mm-2
Longeur 125cm
Poids 121.5 gm
Ailes - 31 gm.
Fuselage - 40 gm
Empen - 12 gm
F. Zaic
120
40
70
140
Fil Al.
Ailes Eiffel 400
Emp. Clark Y
4 x 4
8 x 3
550
350
200
10 x 3
280
125
400
110
3°
-1.5°
150
60%
1.5°
3 x 3
Tube en papaier
6 x 3
5 x 2
~ GAGA ~
Wakefield Design
Bernard Pointel
- France -
A.C. de Normandie
20/10 C.A.P (wire)
10 x 3
450


405
580
905
200
Wing: NACA 6409
Set at 5°
120
70
60
5°
170
-3°
1°
200
Sportsman J
36
1087
Balsa planke fuselage
Consistant 7
Stab St. Cyr 52
Set at 1°
800
IL "PILADE"
Gianni Pavesi
Italy
160
Wt. 815gr


490 Dia.
1:14 Pitch
83
Power
28 Str
90 gr
650 turns
160
85
— MERLU —
2nd PLACE WAKEFIELD
1949
Edgard Sadorin
Italy
75
1.5°
480
4x4 Med. Longerons
2x4 Cross Braces
520
50% C.G
4.5°
900
110
75
110
LD-3
2 Corners
145
F. Zaic
Plans from "MODELLISMO"

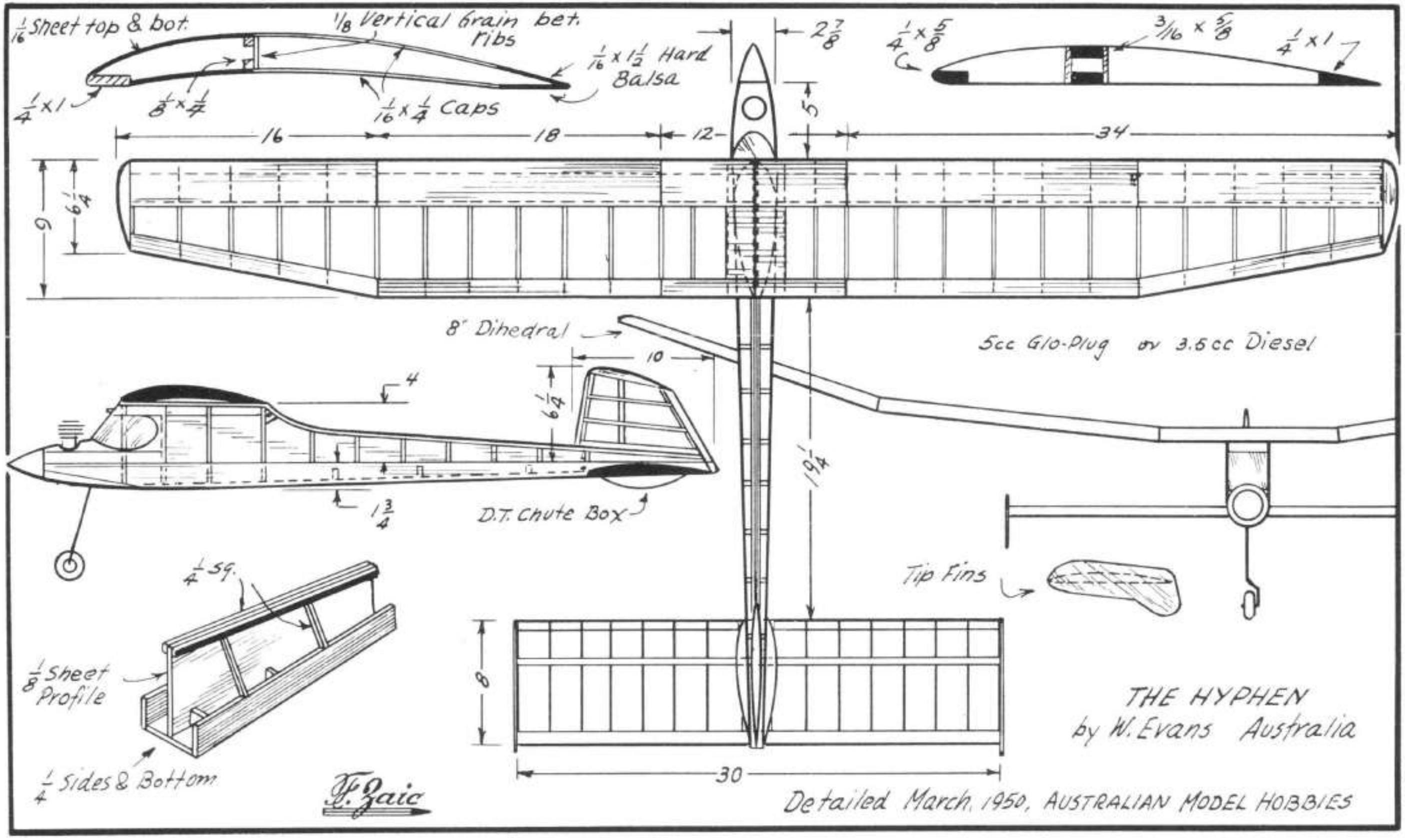


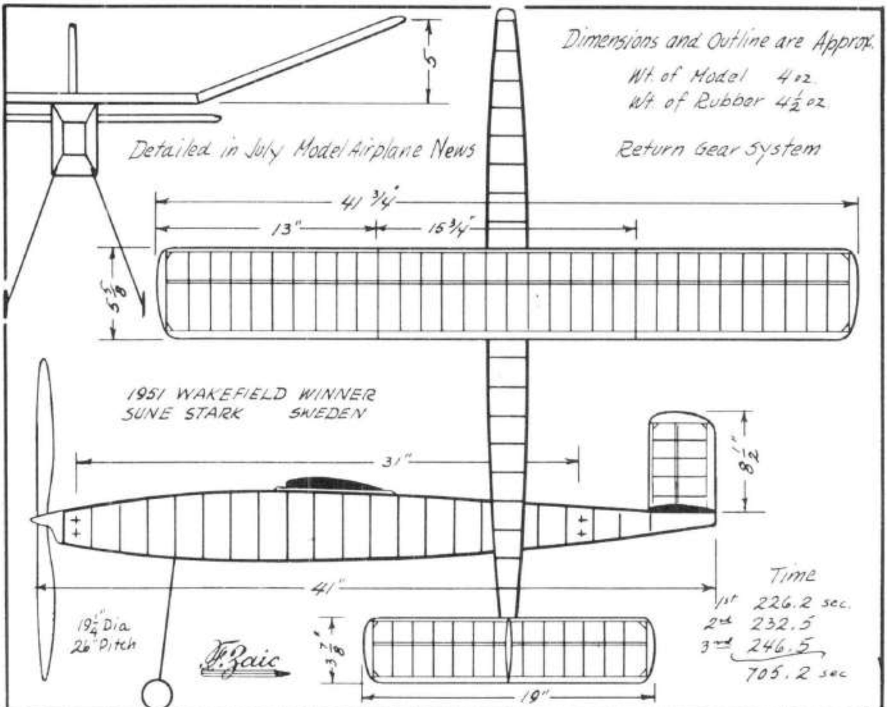


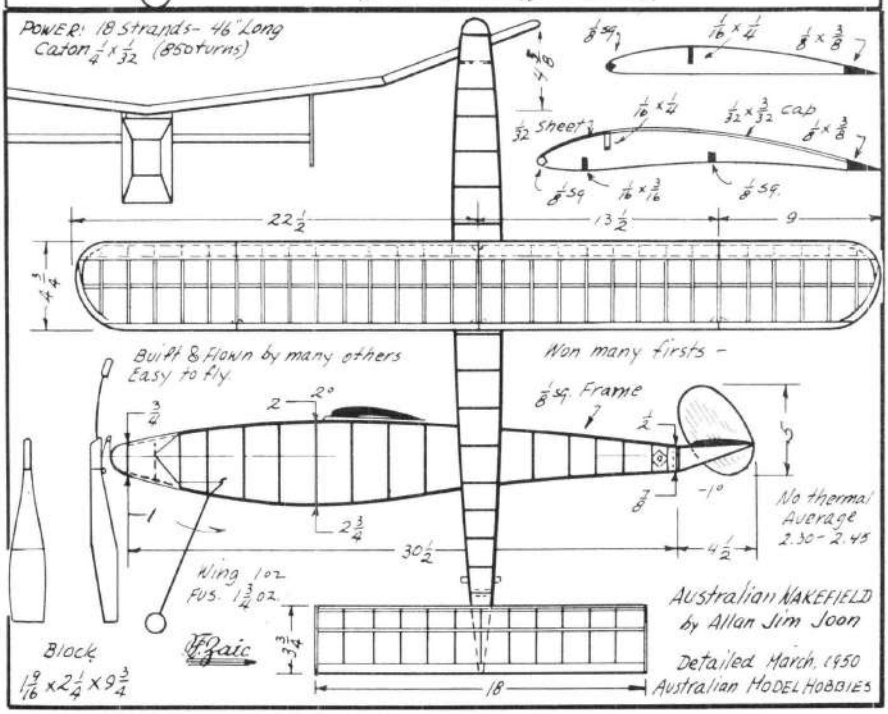
%	Uppr	Lowr
0	1.21	1.21
1.25	2.81	0.10
2.5	3.92	0
5	5.35	0.21
7.5	6.57	0.71
10	7.37	1.21
15	8.78	1.85
20	9.50	2.35
30	9.85	2.78
40	9.71	2.85
50	8.92	2.64
60	7.64	2.14
70	6.21	1.51
80	4.51	1.00
90	2.50	0.57
100	0	0

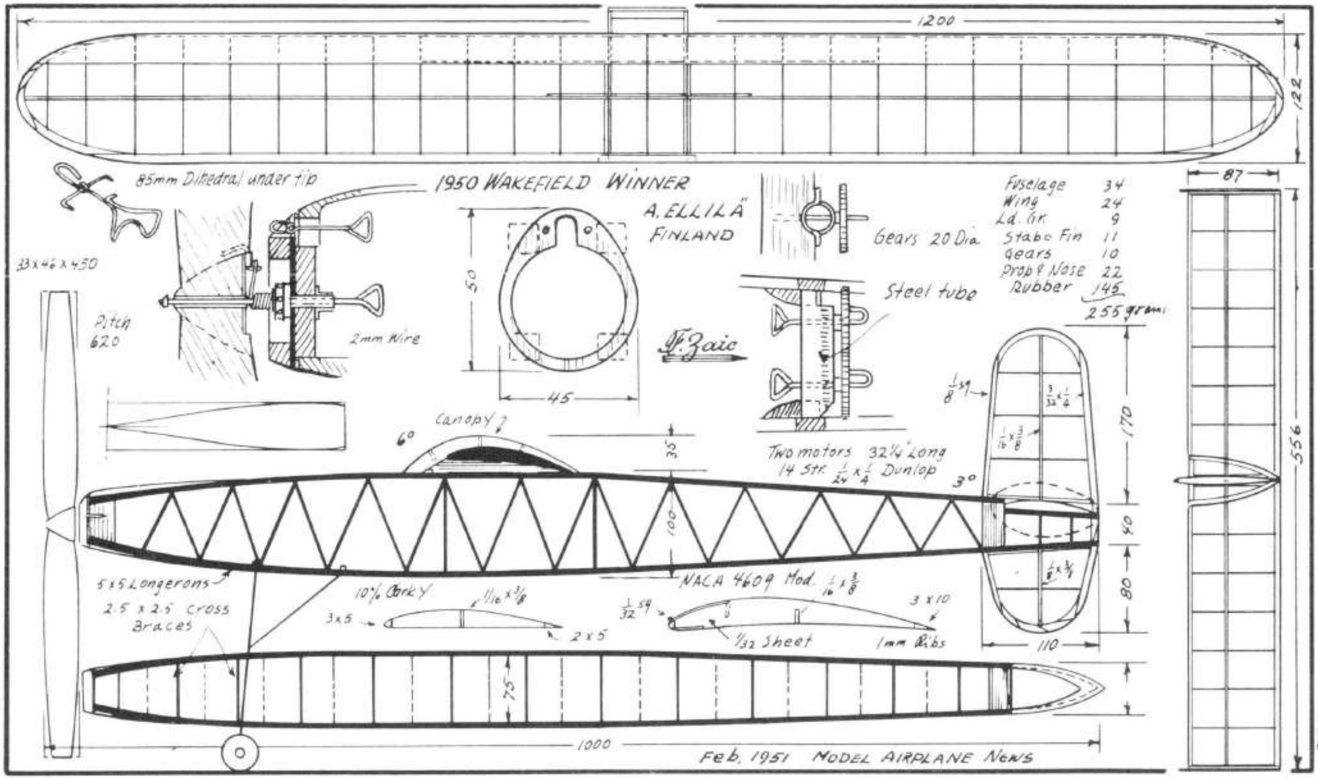
Weights (Poids)

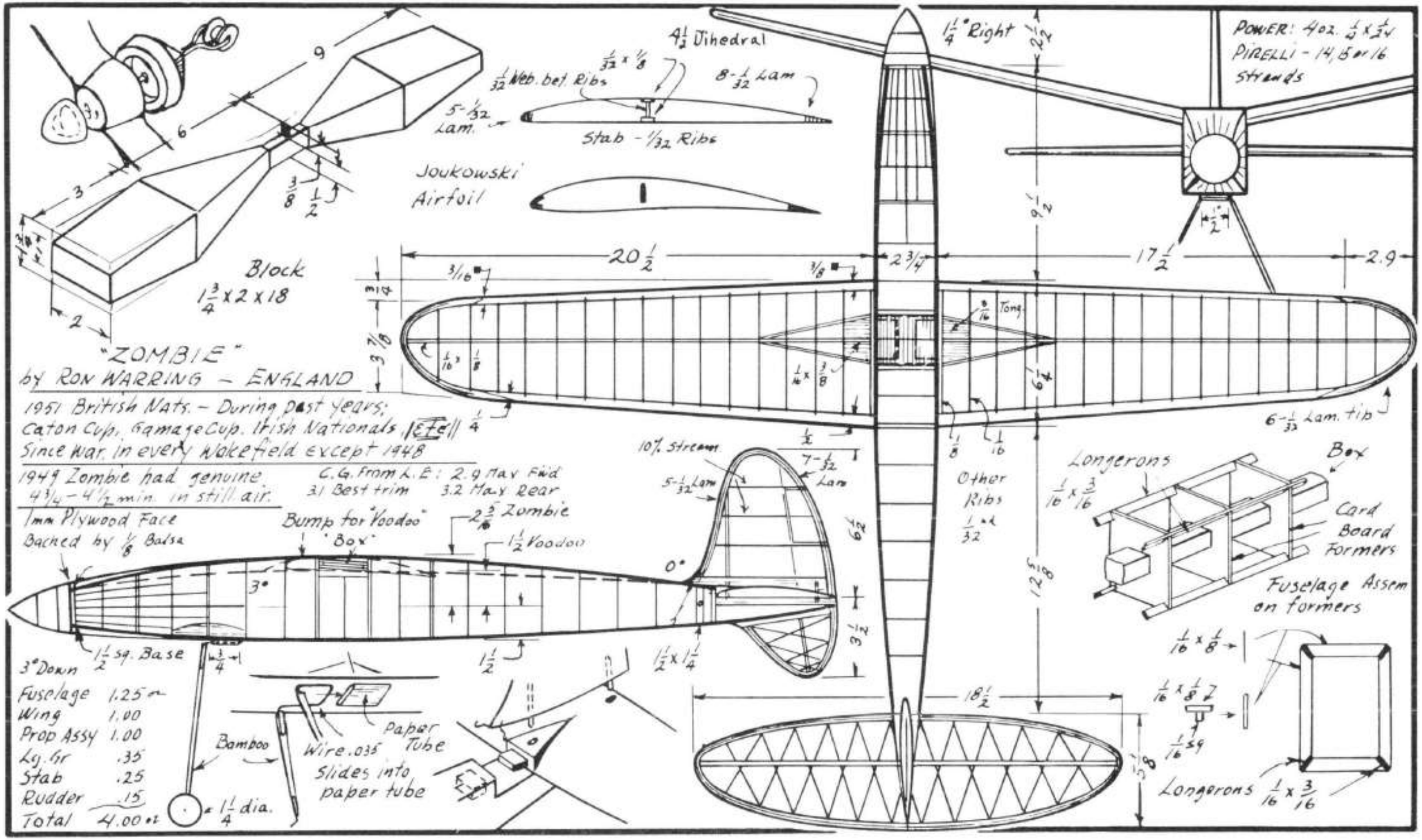
	Frame	Covered	Doped
Ailes & Broch	18	26.0	28.0
Dérives	2.5	2.5	4.0
Stabilisateur	4.5	7.5	9.0
Train	3.0	3.0	3.0
Fuselage & broch	30.0	40.0	42.0
Bloc hélice	23.0	23.0	24.0
Total	81.0	102	110.0


1/16 Sheet top & bot.
1/8 Vertical Grain bet. ribs
1/16 x 1 1/2 Hard Balsa
1/4 x 1
1/8 x 1/4
1/16 x 1/4 Caps
2 7/8
1/4 x 5/8
3/16 x 5/8
1/4 x 1
5
16
18
12
34
9
6 1/4
8" Dihedral
5cc Glo-Plug or 3.5cc Diesel
10
4
6 1/4
1 3/4
D.T. Chute Box
19 1/4
1/4 sq.
1/8 Sheet Profile
1/4 Sides & Bottom
Tip Fins
8
30
THE HYPHEN
by W. Evans Australia
F. Zaic
Detailed March, 1950, AUSTRALIAN MODEL HOBBIES

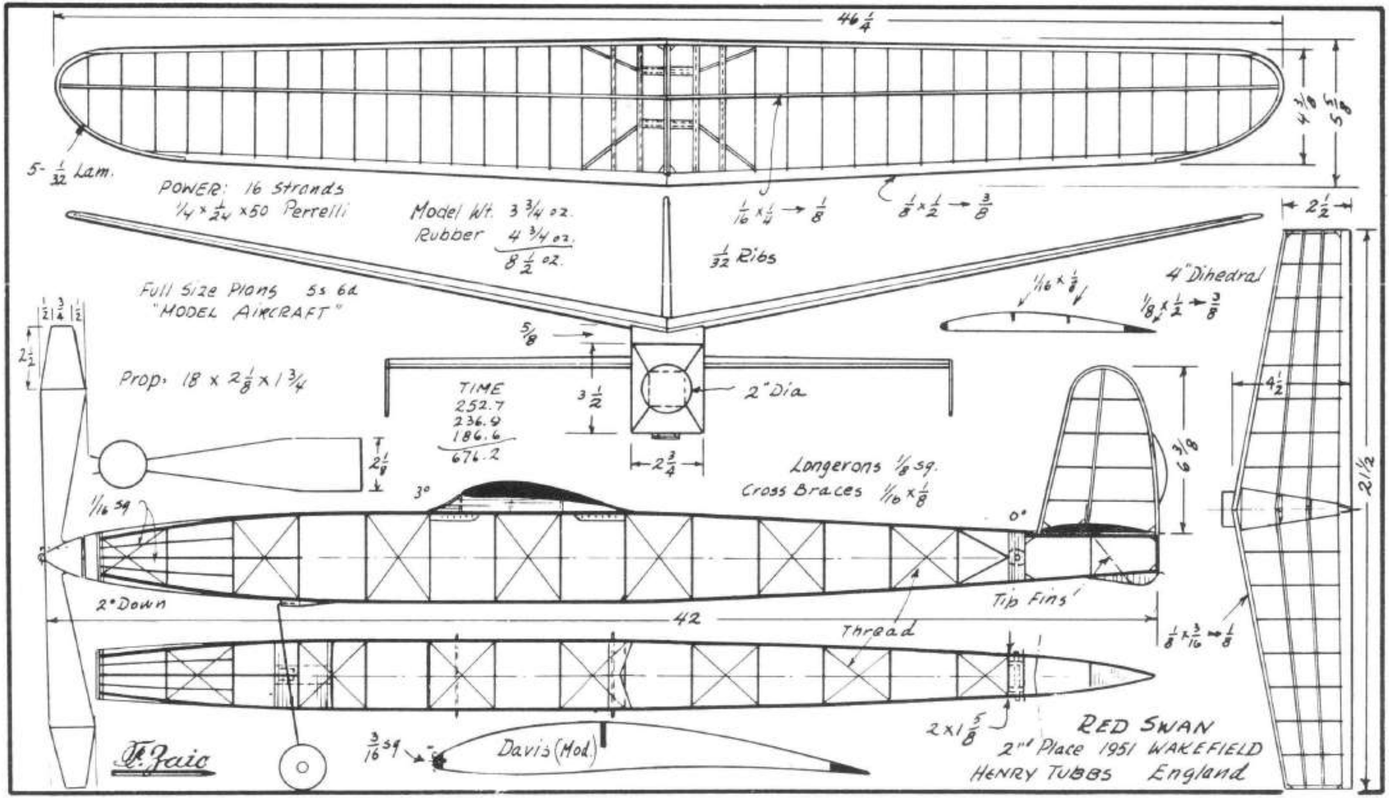

Dimensions and Outline are Approx.
Wt. of Model 4 oz.
Wt. of Rubber 4½ oz.
Detailed in July Model Airplane News
Return Gear System
5
41 3/4"
13"
15 3/4"
5 5/8
1951 WAKEFIELD WINNER
SUNE STARK SWEDEN
31"
8 1/2"
41"
Time
1st 226.2 sec.
2nd 232.5
3rd 246.5
705.2 sec
19¼" Dia
26" Pitch
F. Zaic
3 7/8"
19"

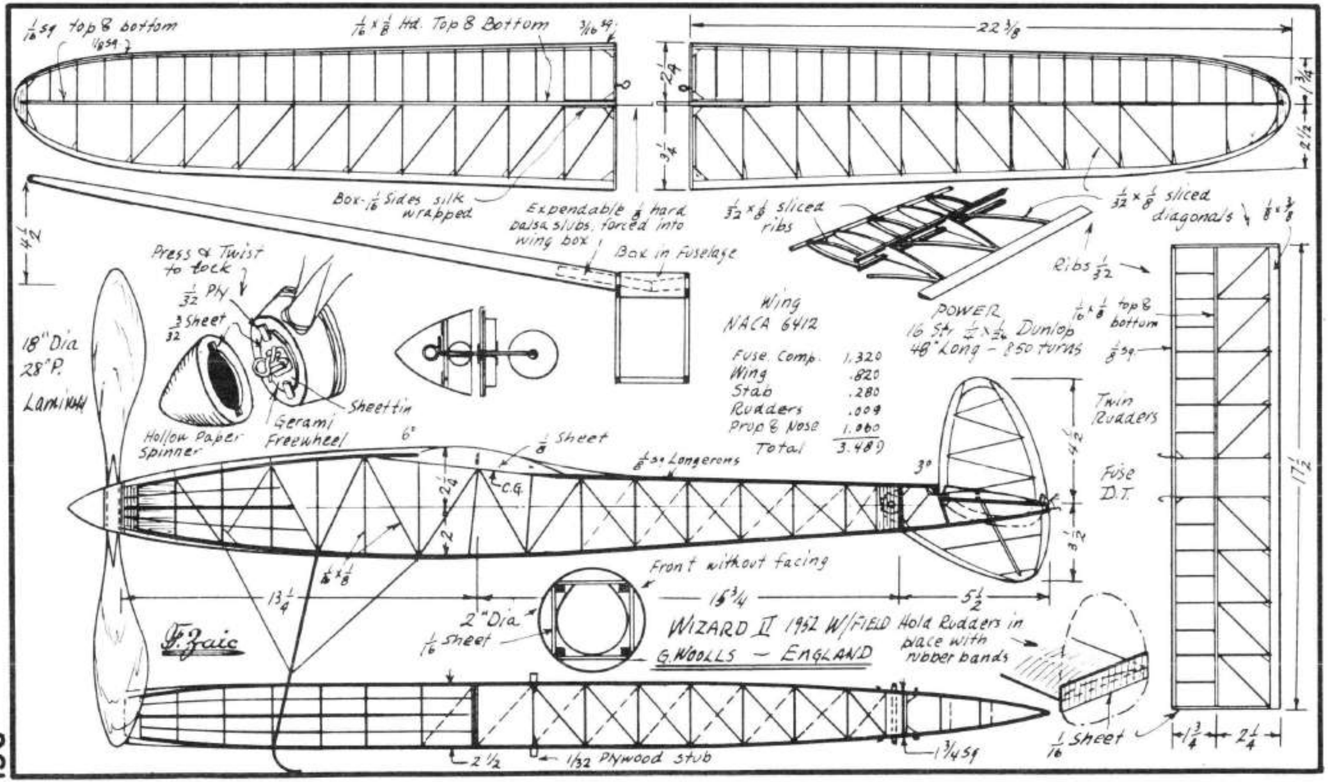

POWER: 18 Strands- 46" Long
Caton ¼ x 1/32 (850 turns)
4 5/8
1/8 sq.
1/16 x ¼
1/8 x 3/8
1/32 sheet
1/16 x ¼
1/32 x 3/32 cap
1/8 x 3/8
1/8 sq
1/16 x 3/16
1/8 sq.
22 ½
13 ½
9
4 ¾
Built & Flown by many others
Easy to fly
Won many firsts -
1/8 sq. Frame
¾
2
2°
½
5
7/8
-1°
1
2 ¾
30 ½
4 ½
No thermal
Average
2.30 - 2.45
Wing 1 oz
Fus. 1 ¾ oz.
Australian WAKEFIELD
by Allan Jim Joon
Detailed March 1950
Australian MODEL HOBBIES
Block
1 9/16 x 2 ¼ x 9 ¾
F. Zaic
3 ¾
18


1200
122
1950 WAKEFIELD WINNER
A. ELLILÄ
FINLAND
85mm Dihedral under tip
33 x 46 x 450
Pitch
620
2mm Wire
50
45
F. Zaic
Gears 20 Dia.
Steel tube
Fuselage 34
Wing 24
Ld. Gr. 9
Stabo Fin 11
Gears 10
Prop & Nose 22
Rubber 145
255 grams
87
556
170
40
80
110
Canopy
6°
35
3°
100
Two motors 32¼" Long
14 Str. 1/24 x 1/4 Dunlop
5 x 5 Longerons
2.5 x 2.5 Cross
Braces
10% Clark Y
3 x 5
2 x 5
NACA 4609 Mod.
1/32 Sheet
3 x 10
1mm Ribs
75
1000
Feb. 1951 MODEL AIRPLANE NEWS

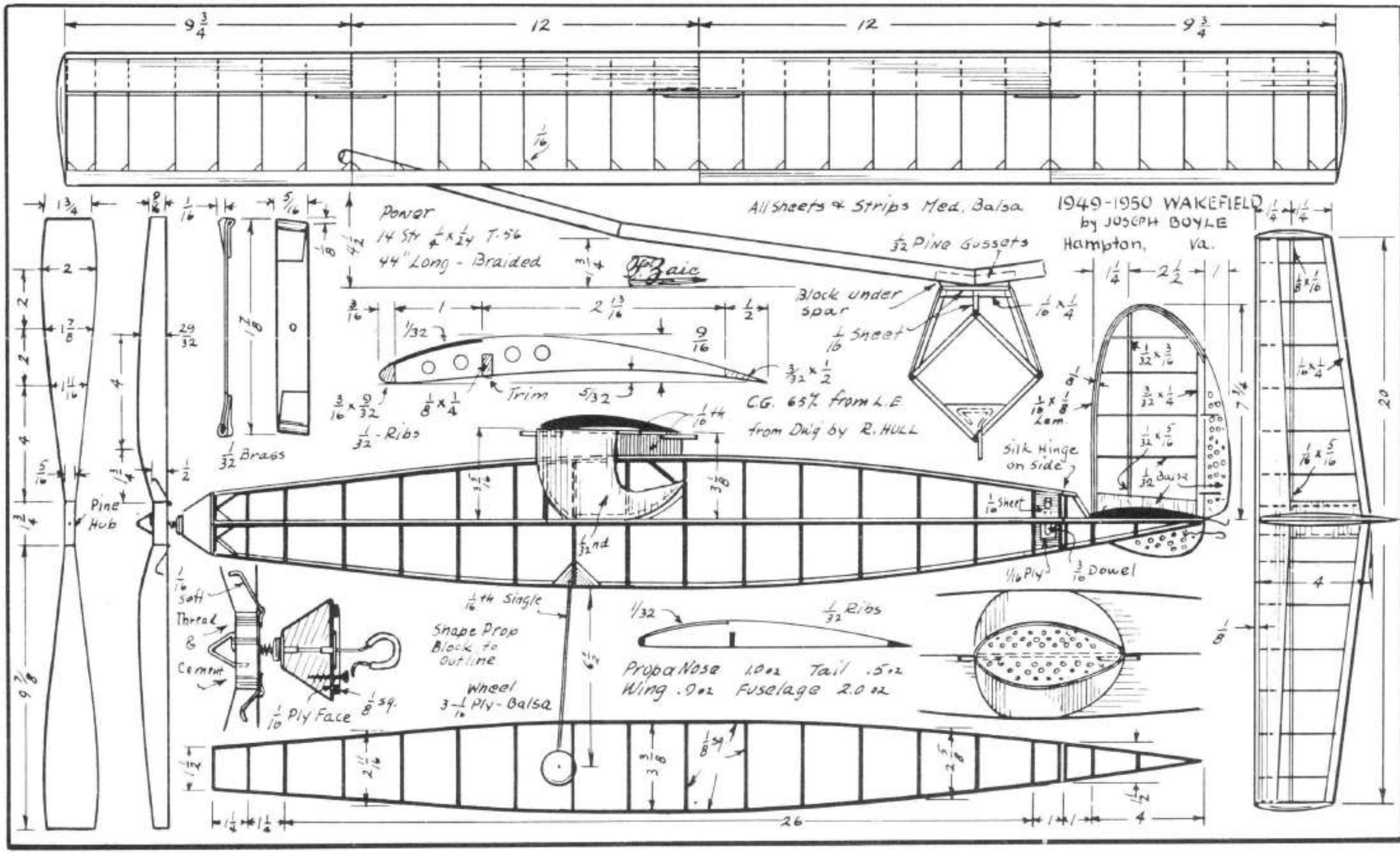


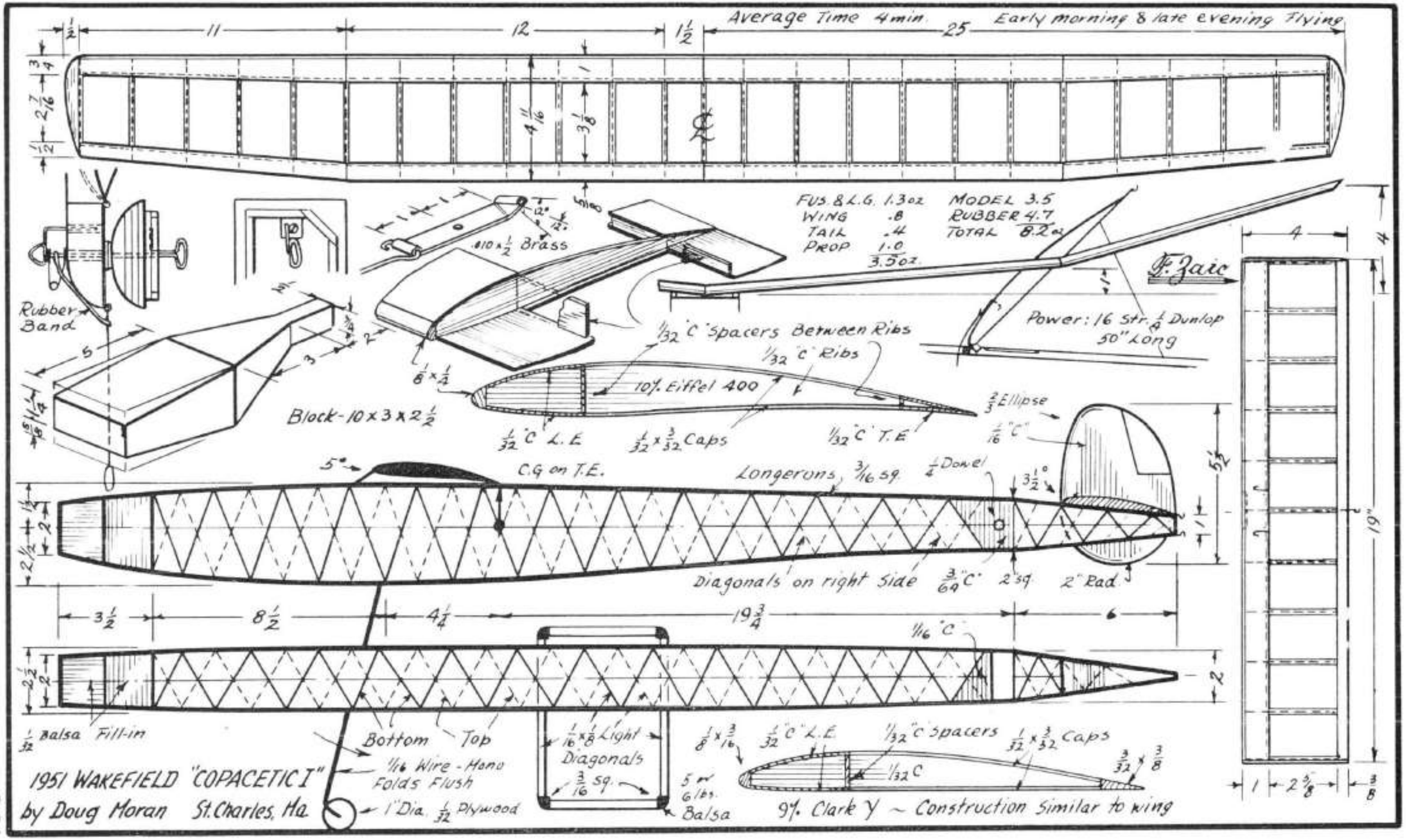
"ZOMBIE"
by RON WARRING – ENGLAND
1951 British Nats. – During past years:
Caton Cup. Gamage Cup. Irish Nationals
Since War. in every Wakefield except 1948
1949 Zombie had genuine
4 3/4 – 4 1/2 min. in still air.
POWER: 4 oz. 1/4 x 1/24
PIRELLI – 14, 15 or 16 strands
Block
1 3/4 x 2 x 18
4 1/2 Dihedral
1/32 Web. bet. Ribs
5 – 1/32 Lam.
8 – 1/32 Lam
Stab – 1/32 Ribs
Joukowski Airfoil
1 1/4° Right
20 1/2
2 3/4
17 1/2
2.9
6 – 1/32 Lam. tip
10% Stream.
5 – 1/32 Lam
7 – 1/32 Lam
Other Ribs 1/32
C.G. From L.E.: 2.9 Max Fwd
3.1 Best trim
3.2 Max Rear
2 3/16 Zombie
1 1/2 Voodoo
Bump for "Voodoo" "Box"
1mm Plywood Face
Backed by 1/8 Balsa
1 1/2 sq. Base
3° Down
Fuselage 1.25 oz
Wing 1.00
Prop Assy 1.00
Lg. Gr .35
Stab .25
Rudder .15
Total 4.00 oz
Bamboo
Wire .035
Paper Tube
Slides into paper tube
1 1/4 dia.
18 1/2
Longerons 1/16 x 3/16
Box
Card Board Formers
Fuselage Assem on formers
Longerons 1/16 x 3/16

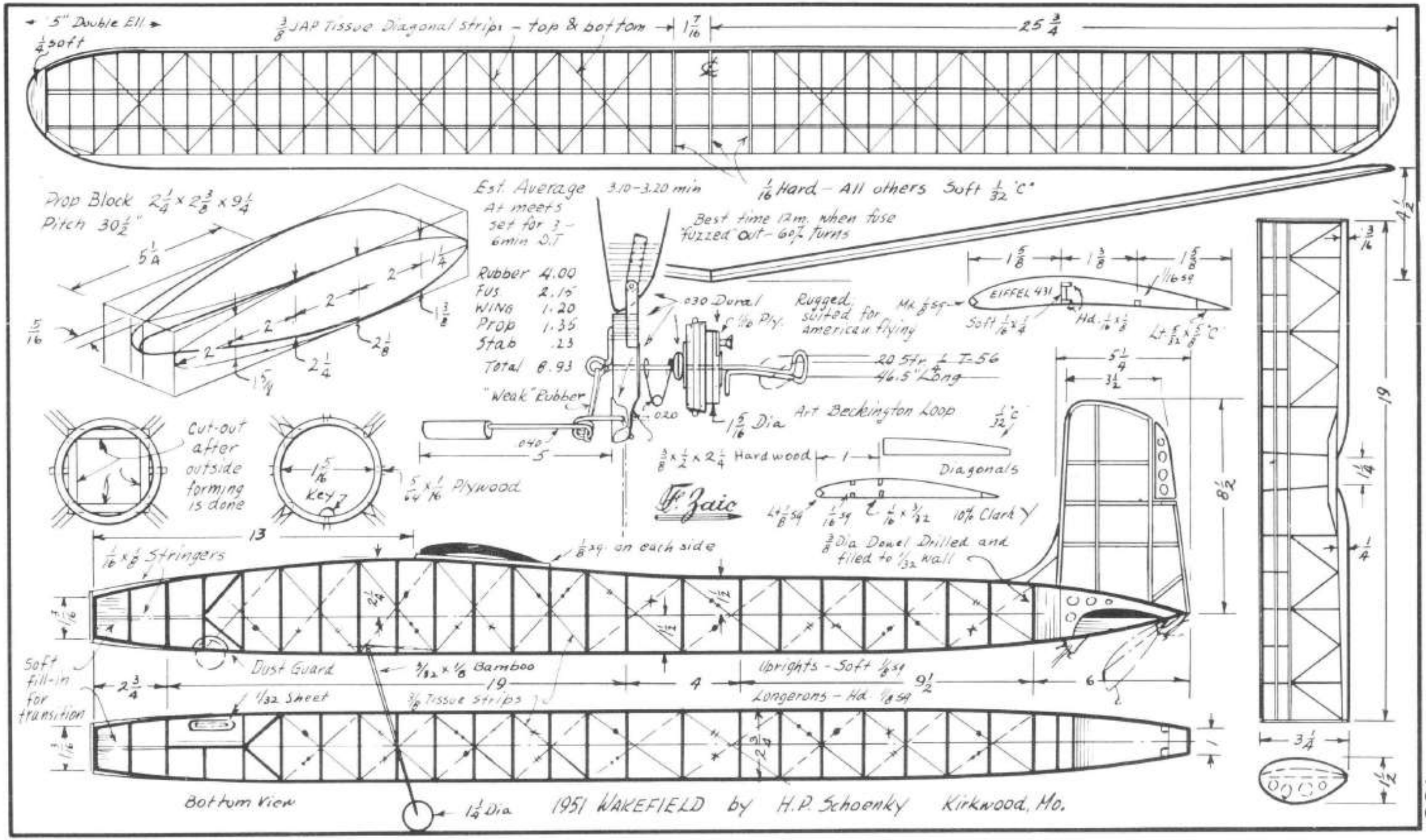

46 1/4
4 3/8
5 5/8
5- 1/32 Lam.
POWER: 16 Strands
1/4 x 1/24 x 50 Perrelli
Model Wt. 3 3/4 oz.
Rubber 4 3/4 oz.
8 1/2 oz.
1/16 x 1/4 → 1/8
1/8 x 1/2 → 3/8
1/32 Ribs
2 1/2
4" Dihedral
1/16 x 1/8
1/8 x 1/2 → 3/8
Full Size Plans 5s 6d
"MODEL AIRCRAFT"
1/2 3/4 1/2
2 1/2
5/8
Prop. 18 x 2 1/8 x 1 3/4
TIME
252.7
236.9
186.6
676.2
3 1/2
2" Dia
2 3/4
2 1/8
6 3/8
4 1/2
21 1/2
Longerons 1/8 sq.
Cross Braces 1/16 x 1/8
3°
1/16 sq
0°
2° Down
Tip Fins
42
Thread
1/8 x 3/16 → 1/8
2 x 1 5/8
3/16 sq
Davis (Mod.)
F. Zaic
RED SWAN
2nd Place 1951 WAKEFIELD
HENRY TUBBS England

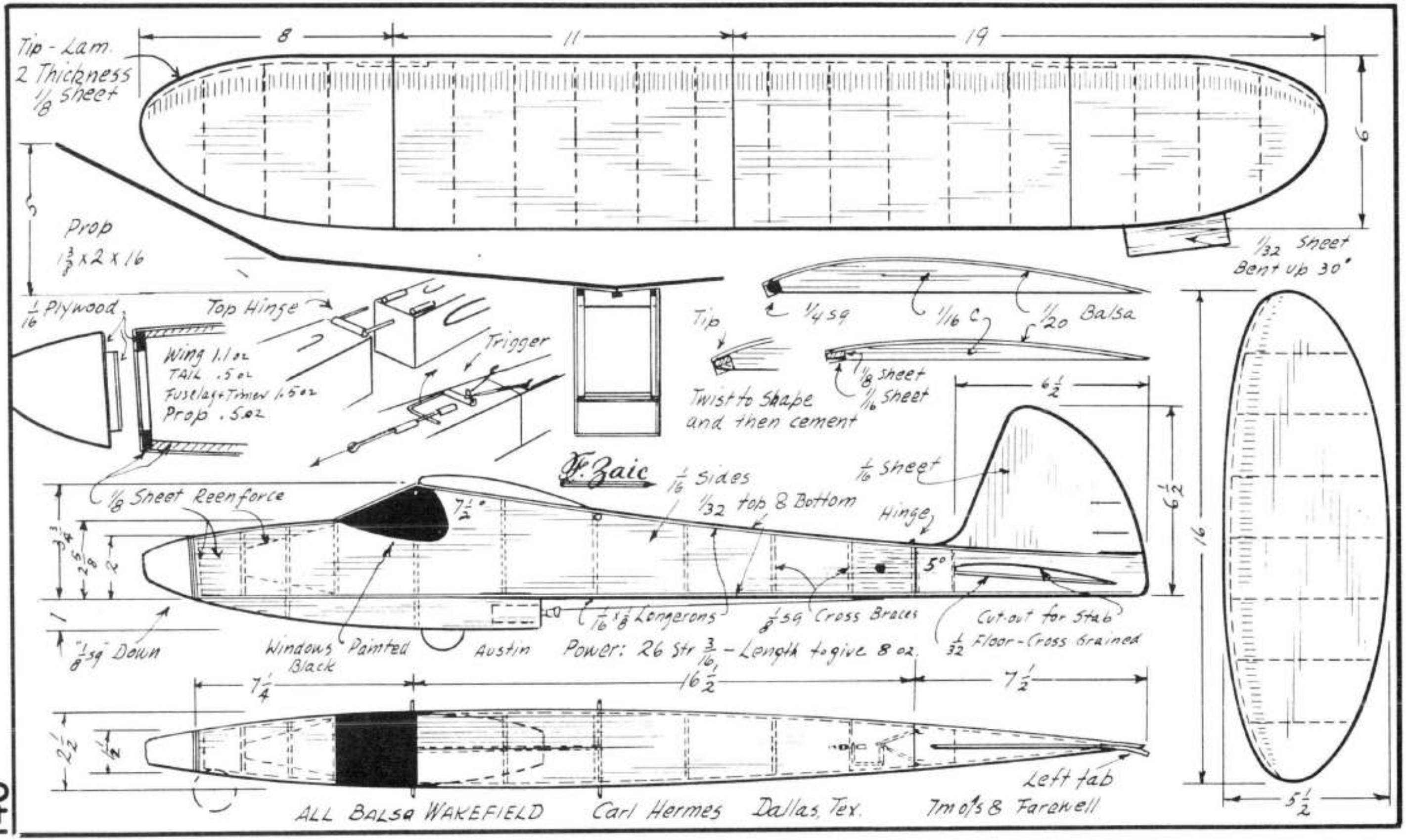


1/16 sq. top & bottom
1/8 sq.
1/16 x 1/8 Hd. Top & Bottom
3/16 sq.
22 3/8
2 1/4
3 1/4
1 3/4
2 1/2
4 1/2
Box-1/16 Sides silk wrapped
Expendable 1/8 hard balsa stubs, forced into wing box
Box in Fuselage
1/32 x 1/8 sliced ribs
1/32 x 1/8 sliced diagonals
1/8 x 3/8
Ribs 1/32
Press & Twist to lock
1/32 Ply
3/32 Sheet
18" Dia
28" P.
Laminated
Sheet tin
Gerami Freewheel
Hollow Paper Spinner
Wing NACA 6412
Fuse. Comp. 1.320
Wing .820
Stab .280
Rudders .009
Prop & Nose 1.060
Total 3.489
POWER
16 Str. 1/4 x 1/24 Dunlop
48" Long - 850 turns
1/16 x 1/8 top & bottom
1/8 sq.
Twin Rudders
Fuse D.T.
17 1/2
6°
1/8 Sheet
1/8 sq. Longerons
C.G.
2 1/4
2
3°
4 1/2
3 1/2
1/16 x 1/8
Front without facing
13 1/4
15 3/4
5 1/2
2" Dia
1/16 sheet
F. Zaic
WIZARD II 1952 W/FIELD
G. WOOLLS - ENGLAND
Hold Rudders in place with rubber bands
1/16 Sheet
1 3/4
2 1/4
2 1/2
1/32 Plywood stub
1 3/4 sq.

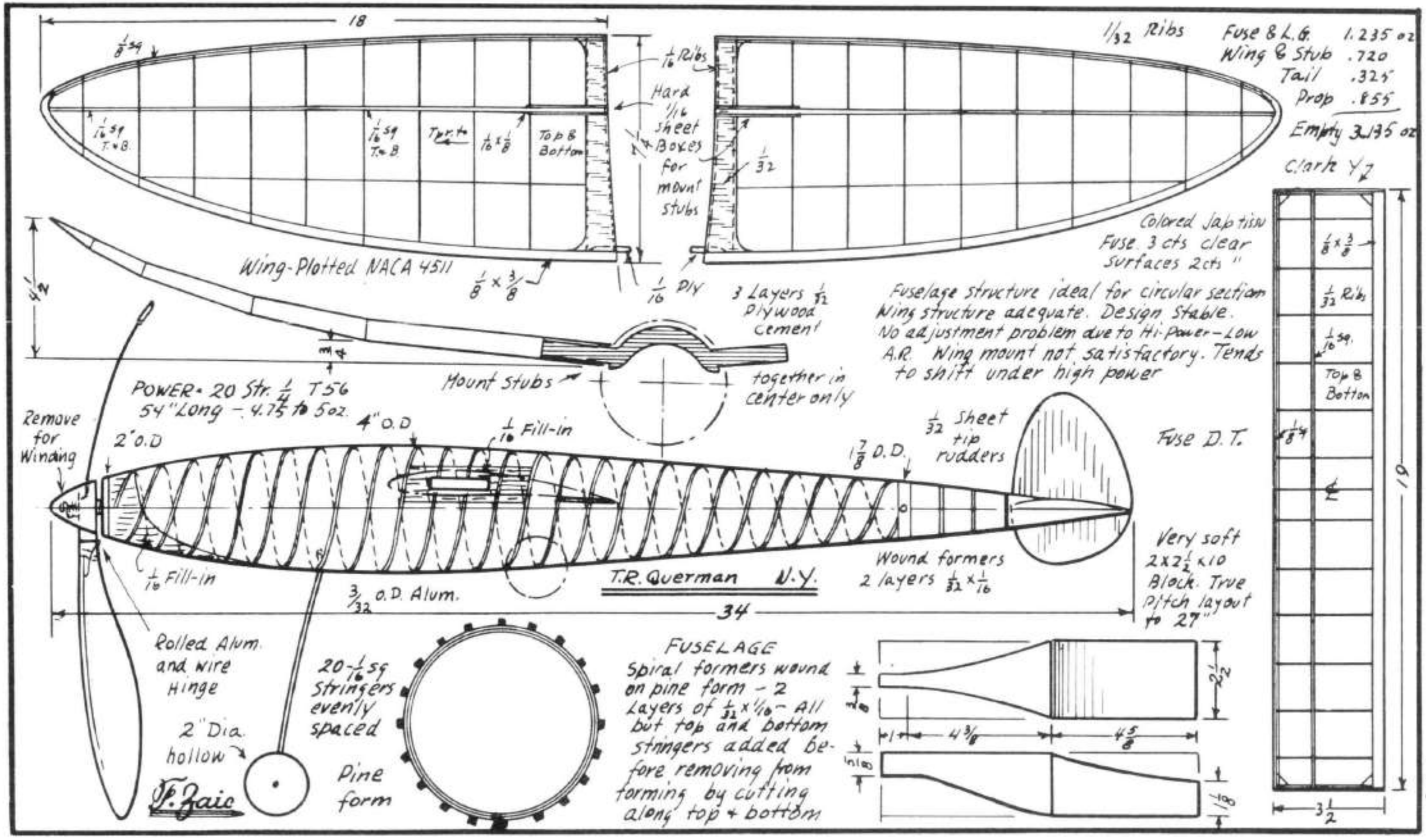

1949-1950 WAKEFIELD
by JOSEPH BOYLE
Hampton, Va.
All Sheets & Strips Med. Balsa
Power
14 Str 1/4 x 1/24 T-56
44" Long - Braided
1/32 Pine Gussets
Block under spar
1/16 Sheet
Trim
C.G. 65% from L.E.
from Dwg by R. HULL
1/32 - Ribs
1/32 Brass
Pine Hub
Silk Hinge on Side
1/32 Balsa
1/16 Sheet
1/16 Ply
3/16 Dowel
1/16 th Single
Shape Prop Block to Outline
Wheel
3-1/16 Ply-Balsa
1/16 Soft Thread & Cement
1/16 Ply Face
1/8 sq.
Prop & Nose 1.0 oz Tail .5 oz
Wing .9 oz Fuselage 2.0 oz
Lam.
9 3/4
12
12
9 3/4
26
20

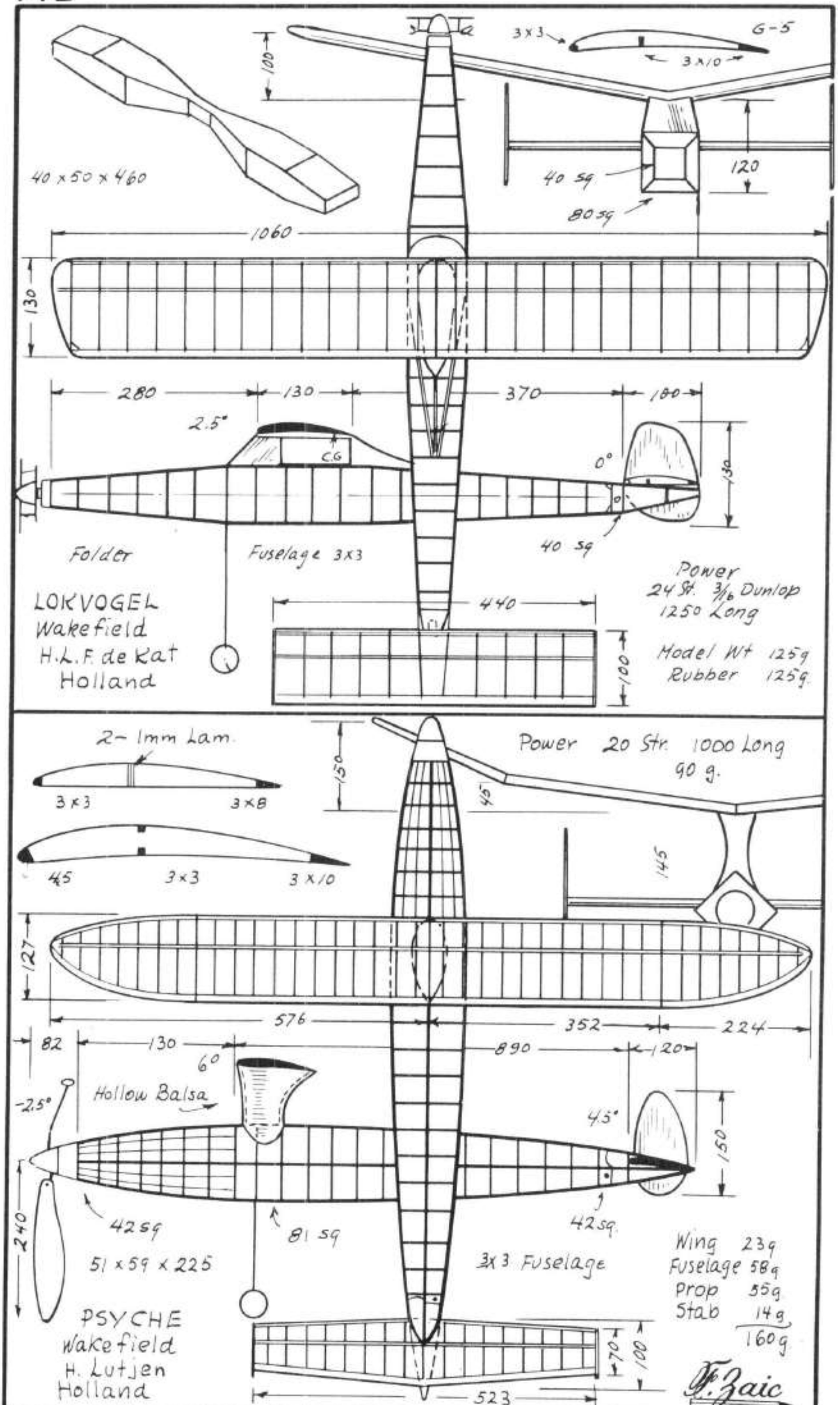

Average Time 4 min.
Early morning & late evening Flying
FUS. & L.G. 1.3 oz
WING .8
TAIL .4
PROP 1.0
3.5 oz.
MODEL 3.5
RUBBER 4.7
TOTAL 8.2 oz
.010 x 1/2 Brass
Rubber Band
Block - 10 x 3 x 2 1/2
1/32 "C" Spacers Between Ribs
1/32 "C" Ribs
10% Eiffel 400
1/32 "C" L.E.
1/32 x 3/32 Caps
1/32 "C" T.E.
Power: 16 Str. 1/4 Dunlop 50" Long
F. Zaic
2/3 Ellipse
1/16 "C"
C.G on T.E.
Longerons 3/16 sq.
1/4 Dowel
Diagonals on right side
3/64 "C"
2 sq.
2" Rad.
1/16 "C"
1/32 Balsa Fill-in
Bottom
Top
1/16 x 1/8 Light Diagonals
3/16 sq.
5 or 6 lbs. Balsa
1/8 x 3/16
1/32 "C" L.E.
1/32 "C" Spacers
1/32 x 3/32 Caps
1/32 C
3/32 x 3/8
9% Clark Y ~ Construction Similar to wing
1/16 Wire - Mono Folds Flush
1" Dia. 1/32 Plywood
1951 WAKEFIELD "COPACETIC I"
by Doug Moran St. Charles, Ma.

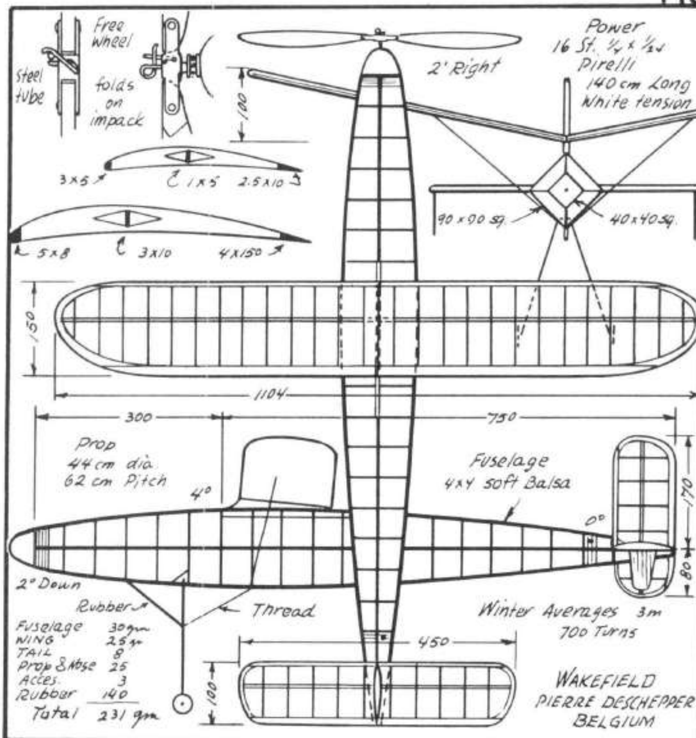

5" Double Ell
1/4 soft
3/8 JAP Tissue Diagonal strips - top & bottom
1 7/16
25 3/4
1/16 Hard - All others Soft 1/32 "C"
Prop Block 2 1/4 x 2 3/8 x 9 1/4
Pitch 30 1/2"
5 1/4
5/16
Est. Average 3.10-3.20 min
At meets set for 3-6 min D.T.
Rubber 4.00
FUS 2.15
WING 1.20
Prop 1.35
Stab .23
Total 8.93
Best time 12m. when fuse "fuzzed out" - 607 turns
.030 Dural
1/16 Ply.
Rugged, suited for american flying
EIFFEL 431
1/16 sq
Hd. 1/16 x 1/8
20 Str. 1/4 T-56
46.5" Long
"Weak" Rubber
.020
.040
1 5/16 Dia
Art Beckington Loop
1/32 "C"
Cut-out after outside forming is done
1 5/16
Key
5/64 x 1/16 Plywood
3/8 x 1/2 x 2 1/4 Hardwood
Diagonals
F. Zaic
10% Clark Y
3/8 Dia Dowel Drilled and filed to 1/32 wall
13
1/16 x 1/8 Stringers
1/8 sq. on each side
Soft fill-in for transition
Dust Guard
3/32 x 1/8 Bamboo
Uprights - Soft 1/8 sq
Longerons - Hd. 1/8 sq
2 3/4
19
4
9 1/2
6
1/32 Sheet
3/8 Tissue Strips
Bottom View
1 1/4 Dia
1951 WAKEFIELD by H.P. Schoenky Kirkwood, Mo.
8 1/2
3 1/4
1 1/2

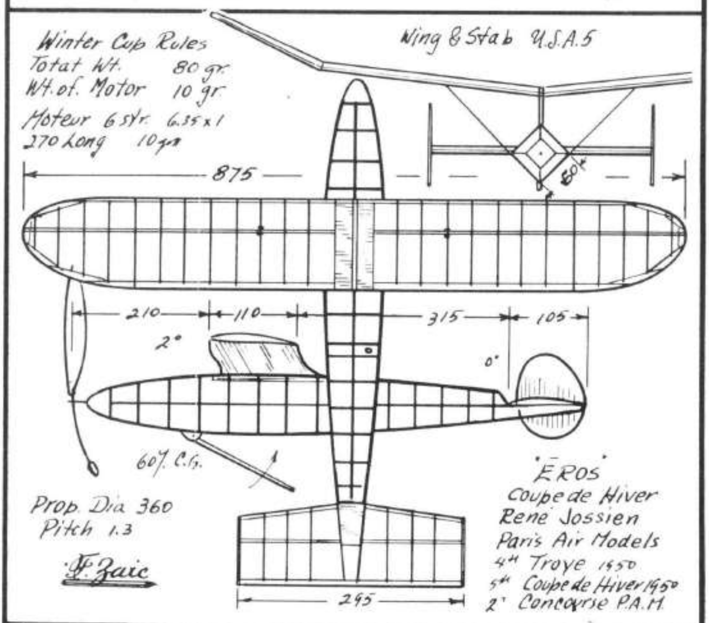


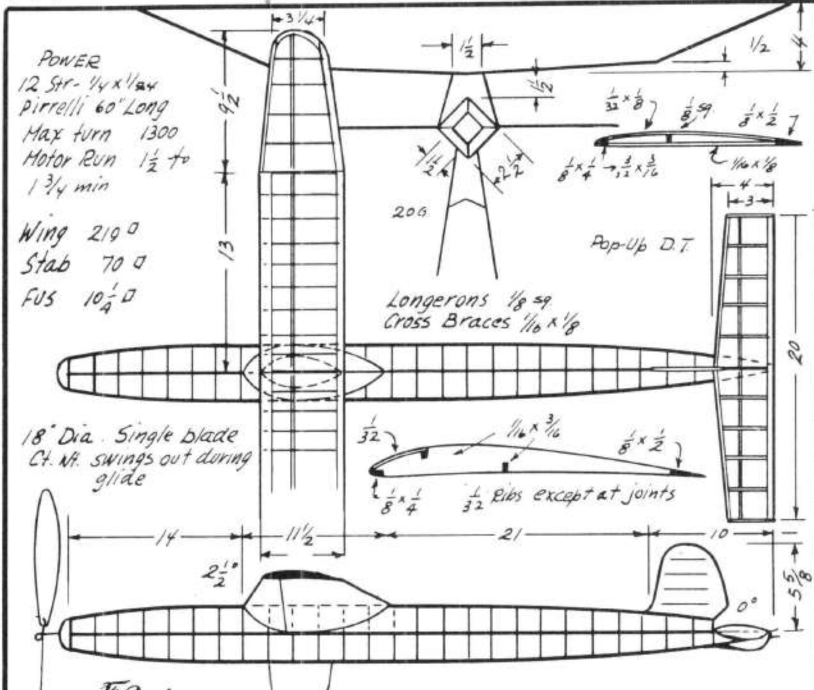
Tip - Lam.
2 Thickness
1/8 Sheet
8
11
19
6
5
Prop
1 3/8 x 2 x 16
1/32 Sheet
Bent up 30°
1/16 Plywood
Top Hinge
Wing 1.1 oz
TAIL .5 oz
Fuselage+Timer 1.5 oz
Prop .5 oz
Trigger
Tip
1/4 sq
1/16 C
1/20 Balsa
1/8 Sheet
1/16 Sheet
Twist to Shape
and then cement
6 1/2
F. Zaic
1/16 Sides
1/32 top & Bottom
1/16 Sheet
Hinge
1/8 Sheet Reenforce
7 1/2°
5°
3 3/4
2 5/8
2
1
16
"1/8 sq" Down
Windows Painted
Black
Austin
1/16 x 1/8 Longerons
1/8 sq Cross Braces
Cut-out for Stab
1/32 Floor-Cross Grained
Power: 26 Str 3/16 - Length to give 8 oz.
7 1/4
16 1/2
7 1/2
2 1/2
1/2
Left tab
5 1/2
ALL BALSA WAKEFIELD
Carl Hermes
Dallas, Tex.
7 mo's & Farewell


18
1/8 sq
1/16 sq T & B.
1/16 sq T & B
Typ. to
1/16 x 1/8
Top & Bottom
1/16 Ribs
Hard 1/16 Sheet Boxes for mount stubs
1/4
1/32
1/32 Ribs
Fuse & L.G. 1.235 oz
Wing & Stub .720
Tail .325
Prop .855
Empty 3.135 oz
Clark Y
Colored Jap tissu
Fuse. 3 cts clear
Surfaces 2 cts "
Wing-Plotted NACA 4511
4 1/2
1/8 x 3/8
1/16 Ply
3 Layers 1/32 Plywood cement
together in center only
Mount Stubs
Fuselage structure ideal for circular section. Wing structure adequate. Design Stable. No adjustment problem due to Hi-power - Low A.R. Wing mount not satisfactory. Tends to shift under high power
1/8 x 3/8
1/32 Ribs
1/16 sq.
Top & Bottom
1/8 sq
POWER - 20 Str. 1/4 T56
54" Long - 4.75 to 5 oz.
Remove for Winding
2" O.D
4" O.D
1/16 Fill-in
1/32 Sheet tip rudders
1 7/8 O.D.
Fuse D.T.
1/16 Fill-in
3/32 O.D. Alum.
T.R. Querman N.Y.
Wound formers 2 layers 1/32 x 1/16
Very soft 2 x 2 1/2 x 10 Block. True pitch layout to 27"
19
34
Rolled Alum. and wire Hinge
20 - 1/16 sq Stringers evenly spaced
2" Dia. hollow
Pine form
FUSELAGE
Spiral formers wound on pine form - 2 Layers of 1/32 x 1/16 - All but top and bottom stringers added before removing from forming by cutting along top & bottom
2 1/2
4 3/8
4 5/8
1 1/8
3 1/2
F. Zaic

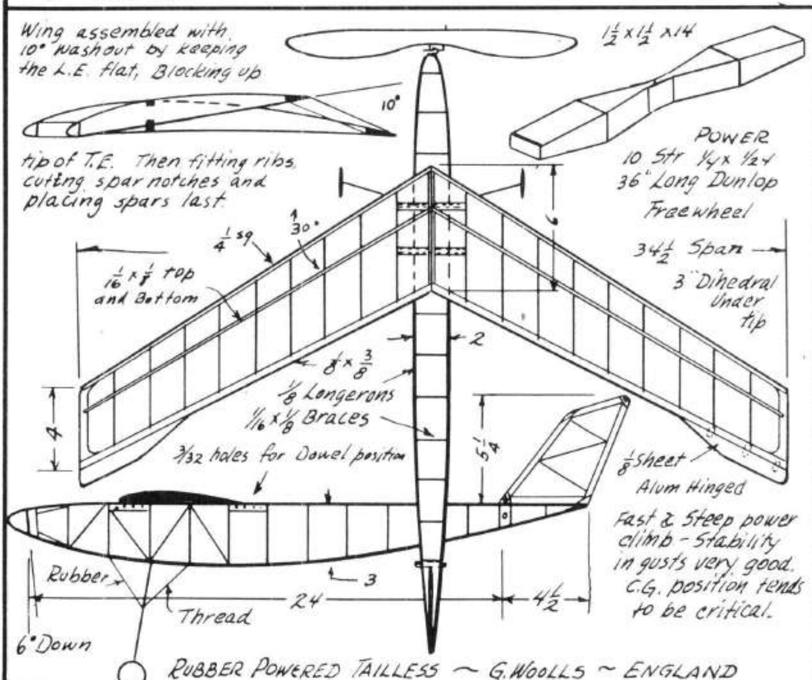

3x3
G-5
3x10
100
40 x 50 x 460
40 sq
120
80 sq
1060
130
280
130
370
180
2.5°
C.G
0°
130
Folder
Fuselage 3x3
40 sq
Power
24 St. 3/16 Dunlop
1250 Long
LOKVOGEL
Wakefield
H.L.F. de Kat
Holland
440
100
Model Wt 125g
Rubber 125g
2- 1mm Lam.
150
Power 20 Str. 1000 Long
90 g.
3x3
3x8
45
145
45
3x3
3x10
127
576
352
224
82
130
890
120
6°
-2.5°
Hollow Balsa
4.5°
150
240
42 sq
81 sq
42 sq
51 x 59 x 225
3x3 Fuselage
Wing 23g
Fuselage 58g
Prop 55g
Stab 14g
160g
PSYCHE
Wakefield
H. Lutjen
Holland
70
100
523
F. Zaic


Free wheel
Steel tube
folds on impack
Power
16 St. 1/4 x 1/24
Pirelli
140 cm Long
White tension
2' Right
100
3x5
℄ 1x5
2.5x10
5x8
℄ 3x10
4x150
90x90 sq.
40x40 sq.
150
1104
300
750
Prop
44 cm dia.
62 cm Pitch
4°
Fuselage
4x4 soft Balsa
0°
170
80
2° Down
Rubber
Thread
Winter Averages 3m
700 Turns
Fuselage 30 gm
WING 25 gm
TAIL 8
Prop & Nose 25
Acces. 3
Rubber 140
Total 231 gm
450
100
WAKEFIELD
PIERRE DESCHEPPER
BELGIUM

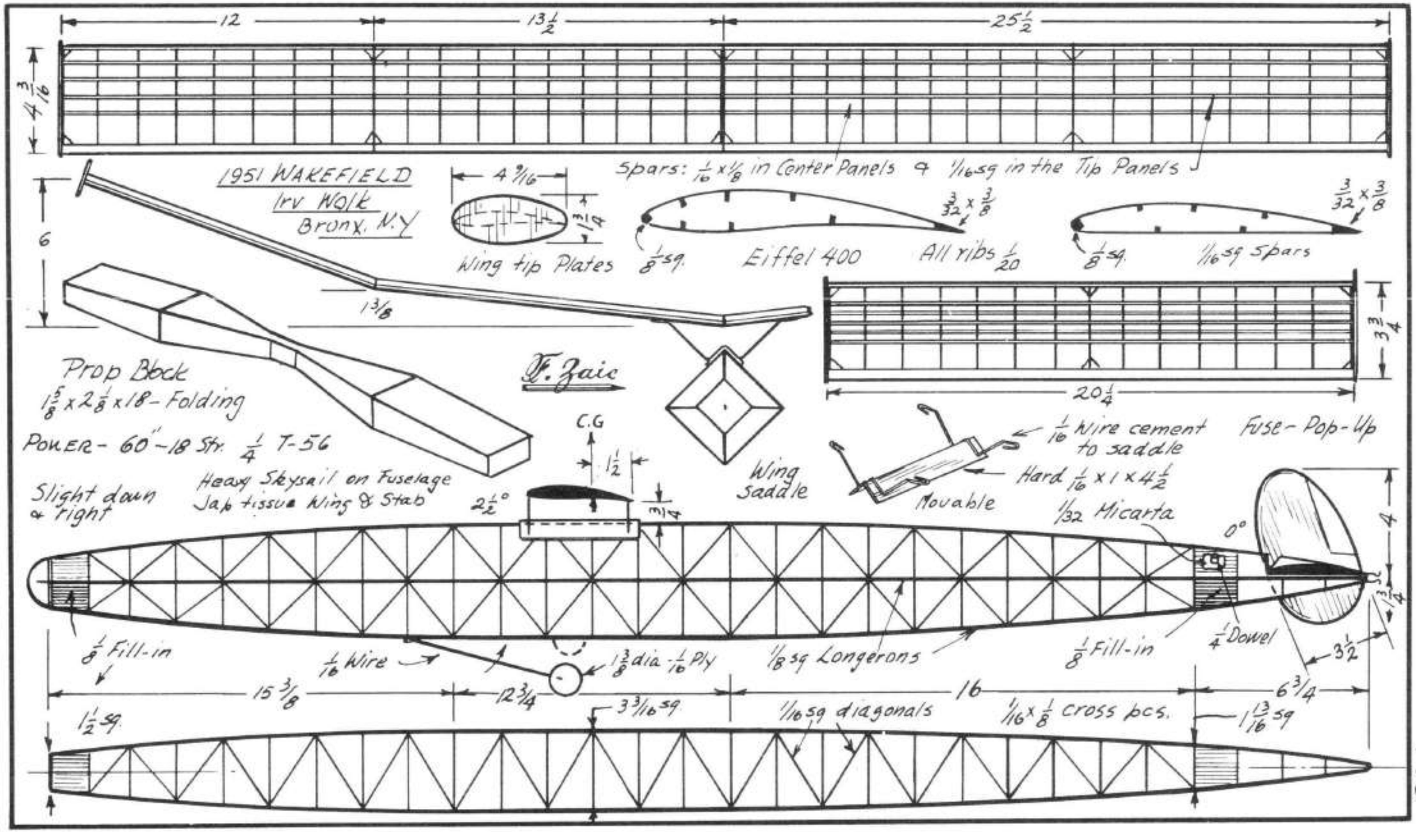

Winter Cup Rules
Totat Wt. 80 gr.
Wt. of Motor 10 gr.
Moteur 6 str. 6.35 x 1
270 Long 10 gm
Wing & Stab U.S.A.5
875
80
210
110
315
105
2°
0°
60% C.G.
Prop. Dia 360
Pitch 1.3
F. Zaic
"EROS"
Coupe de Hiver
René Jossien
Paris Air Models
4th Troye 1950
5th Coupe de Hiver 1950
2' Concourse P.A.M.
295



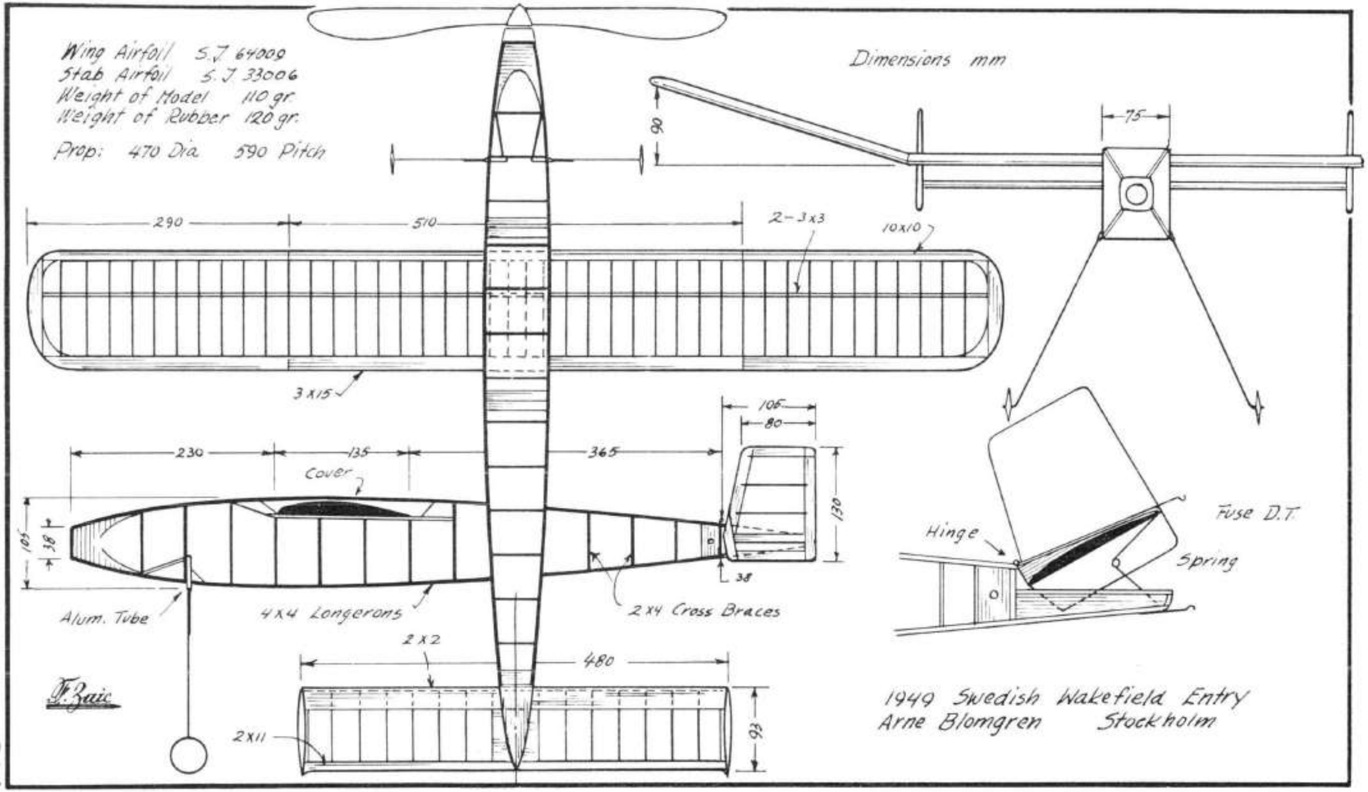
WAKEFIELD ~ N.G. MARCUS ~ ENGLAND

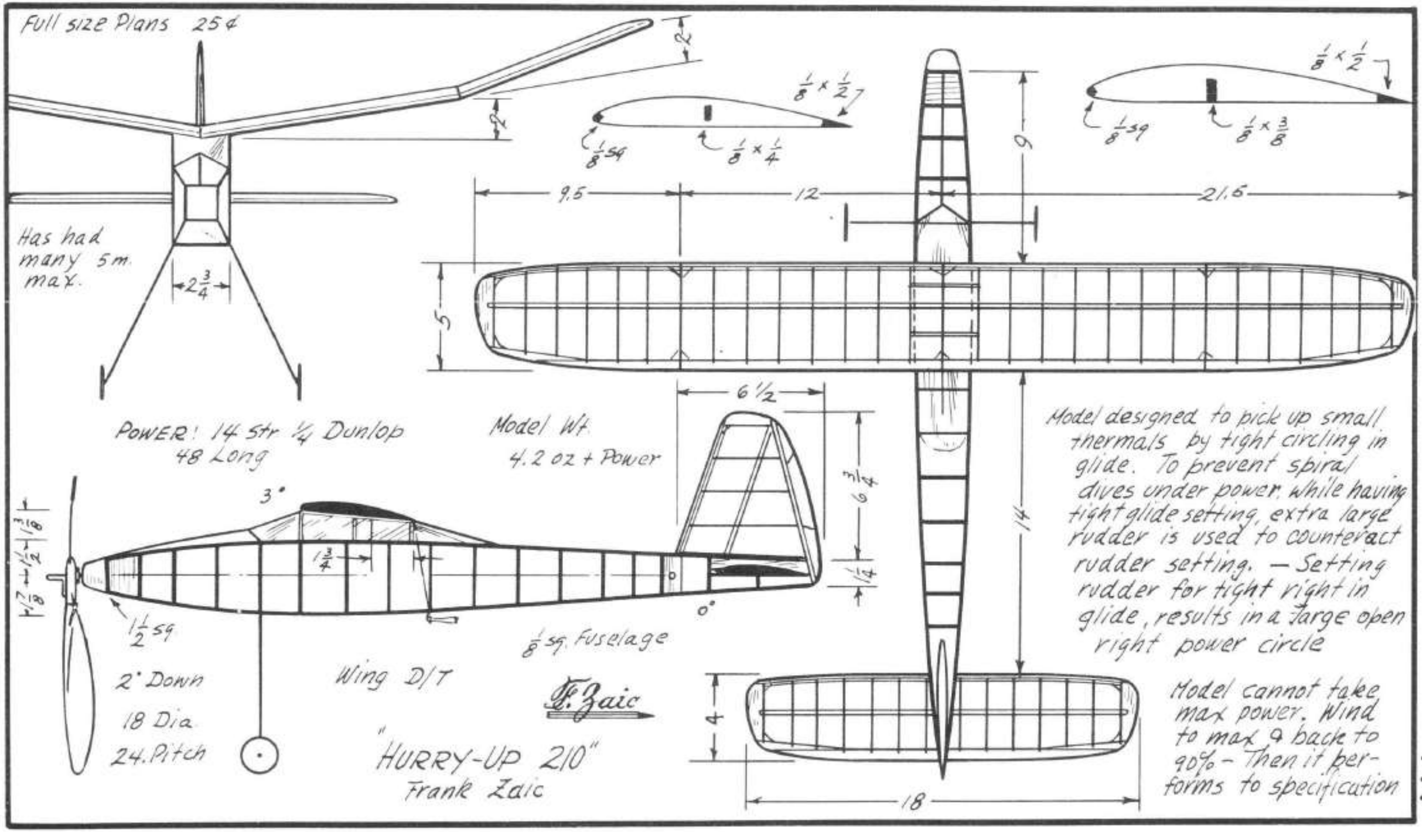


RUBBER POWERED TAILLESS ~ G. WOOLLS ~ ENGLAND

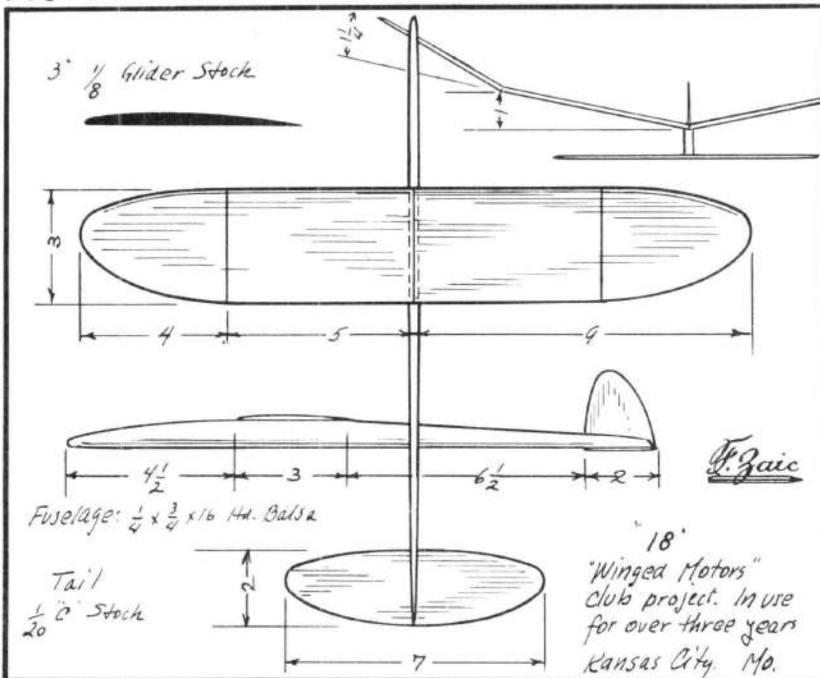


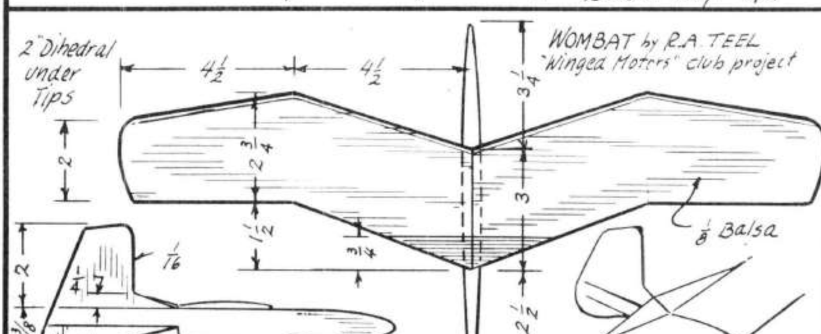
1951 WAKEFIELD
Irv Wolk
Bronx, N.Y
12
13 1/2
25 1/2
4 3/16
Spars: 1/16 x 1/8 in Center Panels & 1/16 sq in the Tip Panels
4 9/16
1 3/4
Wing tip Plates
3/32 x 3/8
1/8 sq.
Eiffel 400
All ribs 1/20
1/16 sq Spars
6
1 3/8
3 3/4
20 1/4
Prop Block
1 5/8 x 2 1/8 x 18 - Folding
F. Zaic
POWER - 60" - 18 Str. 1/4 T-56
C.G
1 1/2
Wing saddle
1/16 Wire cement to saddle
Fuse - Pop-Up
Hard 1/16 x 1 x 4 1/2
Movable
1/32 Micarta
Slight down & right
Heavy Skysail on Fuselage
Jap tissue Wing & Stab
2 1/2°
3/4
0°
4
1 3/4
1/8 Fill-in
1/16 Wire
1 3/8 dia - 1/16 Ply
1/8 sq Longerons
1/8 Fill-in
1/4 Dowel
3 1/2
15 3/8
12 3/4
16
6 3/4
3 3/16 sq
1 1/2 sq.
1/16 sq diagonals
1/16 x 1/8 cross pcs.
1 13/16 sq

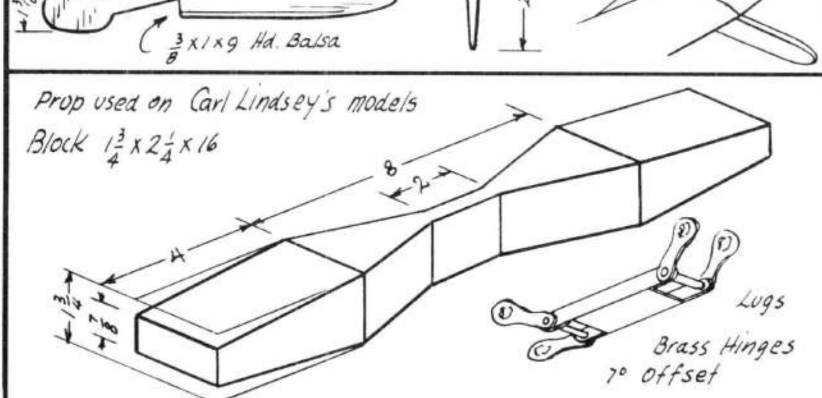

Wing Airfoil S.J 64009
Stab Airfoil S.J 33006
Weight of Model 110 gr.
Weight of Rubber 120 gr.
Prop: 470 Dia 590 Pitch
Dimensions mm
90
75
290
510
2-3x3
10x10
3x15
106
80
230
135
365
Cover
105
38
130
38
Fuse D.T.
Hinge
Spring
Alum. Tube
4x4 Longerons
2x4 Cross Braces
2x2
480
2x11
93
F. Zaic
1949 Swedish Wakefield Entry
Arne Blomgren Stockholm

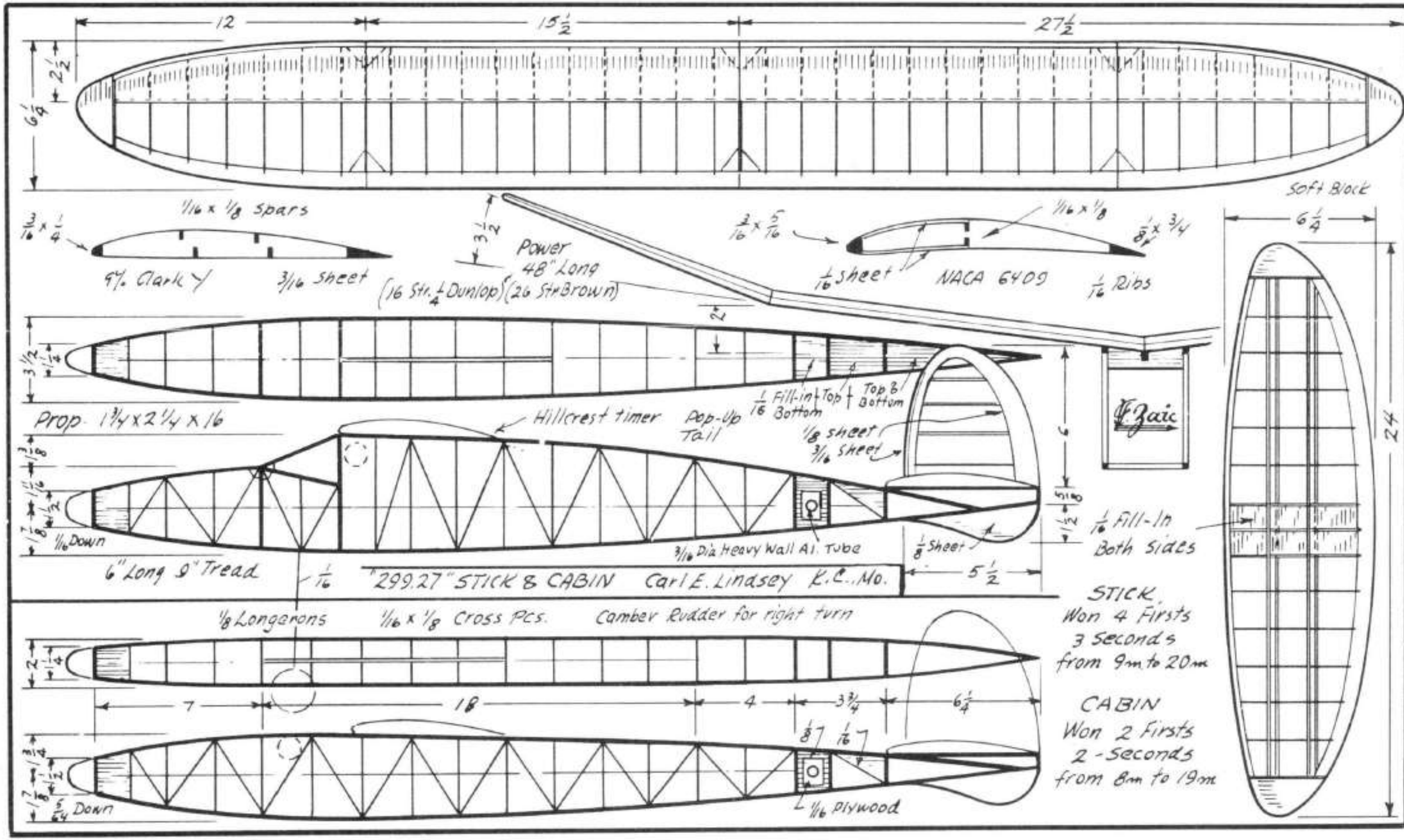


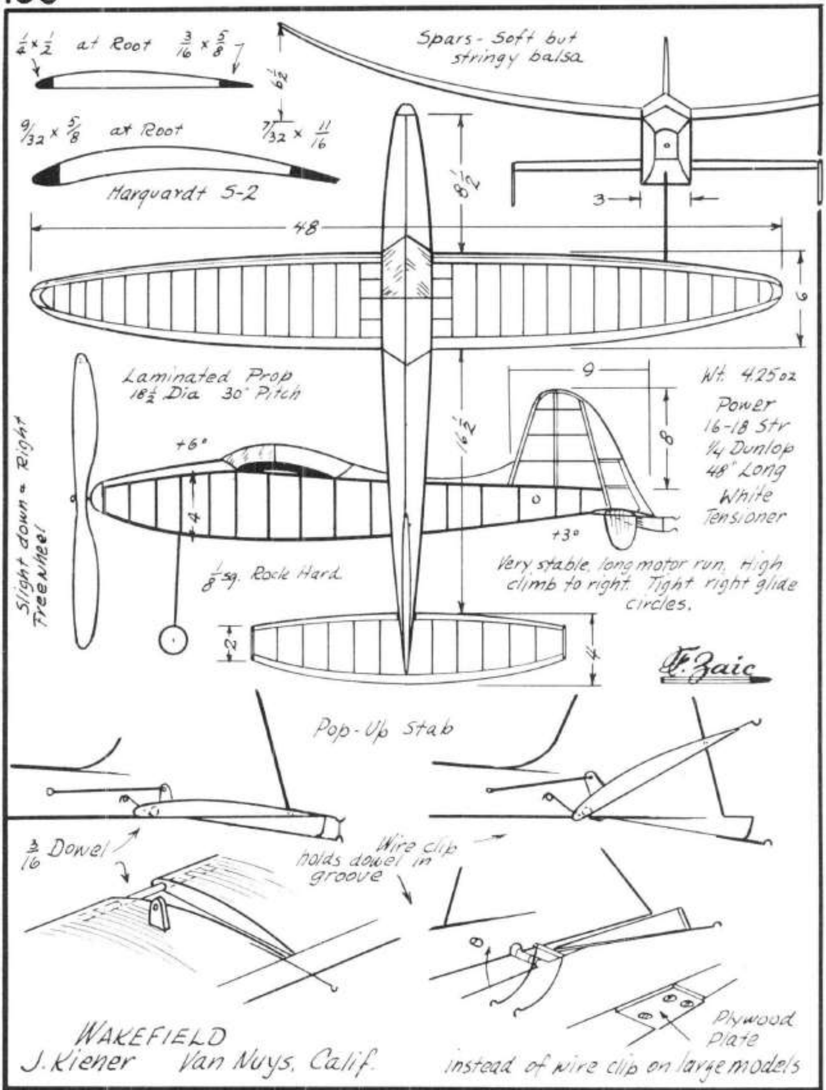
Full size Plans 25¢
Has had many 5m. max.
POWER! 14 Str 1/4 Dunlop 48 Long
Model Wt. 4.2 oz + Power
Model designed to pick up small thermals by tight circling in glide. To prevent spiral dives under power while having tight glide setting, extra large rudder is used to counteract rudder setting. — Setting rudder for tight right in glide, results in a large open right power circle
Model cannot take max power. Wind to max & back to 90% - Then it performs to specification
1/8 sq. Fuselage
Wing D/T
2° Down
18 Dia
24. Pitch
1 1/2 sq
"HURRY-UP 210"
Frank Zaic
F. Zaic

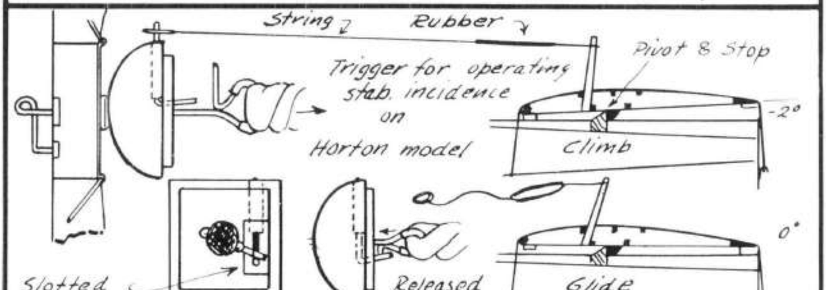

3" 1/8 Glider Stock
1 1/4
1
3
4
5
9
4 1/2
3
6 1/2
2
F. Zaic
Fuselage: 1/4 x 3/4 x 16 Hd. Balsa
Tail
1/20 "C" Stock
2
7
18"
"Winged Motors"
club project. In use
for over three years
Kansas City. Mo.

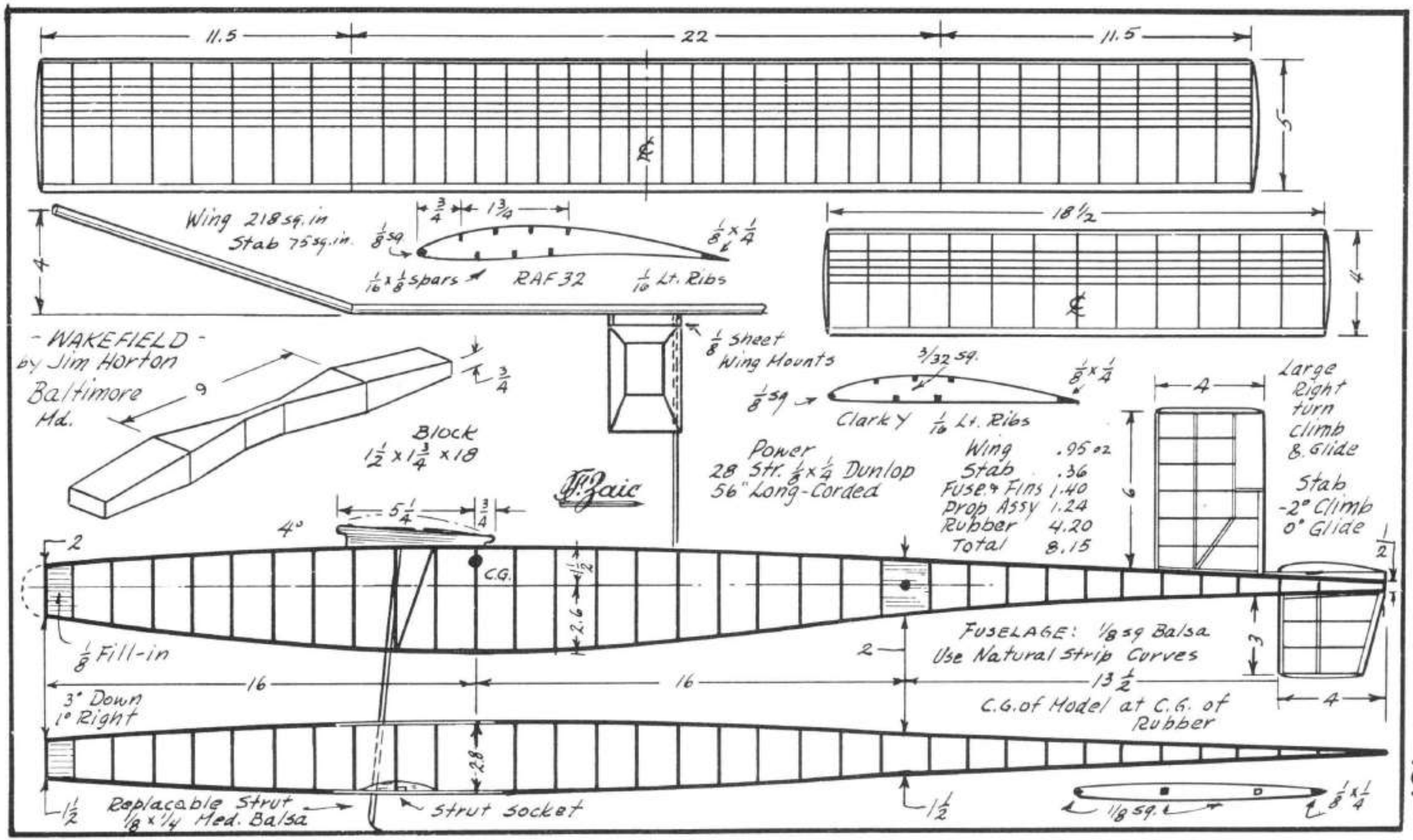

2" Dihedral
under
Tips
4 1/2
4 1/2
WOMBAT by R.A. TEEL
"Winged Motors" club project
3 1/4
2 3/4
2
3
1 1/2
3/4
1/16
1/4
2
3/8
1/8 Balsa
2 1/2
3/8 x 1 x 9 Hd. Balsa


Prop used on Carl Lindsey's models
Block 1 3/4 x 2 1/4 x 16
8
2
4
Lugs
Brass Hinges
7° Offset

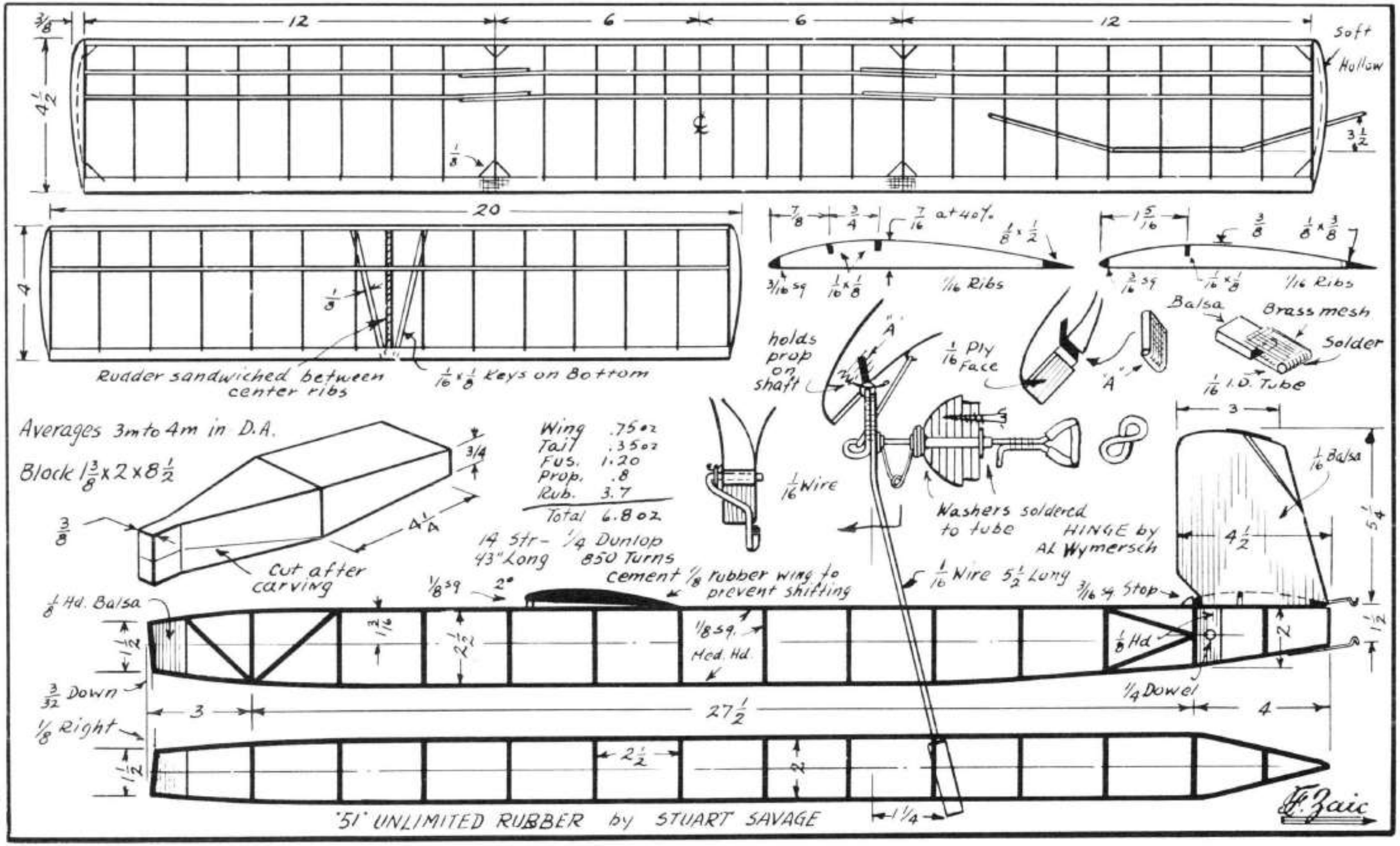

12
15 1/2
27 1/2
2 1/2
6 1/4
1/16 x 1/8 Spars
3/16 x 1/4
9% Clark Y
3/16 Sheet
3 1/2
Power
48" Long
(16 Str. 1/4 Dunlop)(26 Str Brown)
3/16 x 5/16
1/16 x 1/8
1/8 x 3/4
1/16 Sheet
NACA 6409
1/16 Ribs
Soft Block
6 1/4
3 1/2
1/4
2"
1/16 Fill-in Top
Bottom
Top & Bottom
Prop 1 3/4 x 2 1/4 x 16
Hillcrest timer
Pop-Up Tail
1/8 sheet
3/16 sheet
6
F. Zaic
24
1/16 Down
1/16 Fill-In
Both Sides
3/16 Dia Heavy Wall Al. Tube
1/8 Sheet
6" Long 9" Tread
1/16
"299.27" STICK & CABIN Carl E. Lindsey K.C., Mo.
5 1/2
1/8 Longerons
1/16 x 1/8 Cross Pcs.
Camber Rudder for right turn
STICK
Won 4 Firsts
3 Seconds
from 9m to 20m
2
1/4
7
18
4
3 3/4
6 1/4
CABIN
Won 2 Firsts
2 - Seconds
from 8m to 19m
1/8
1/16
5/64 Down
1/16 Plywood


1/4 x 1/2 at Root
3/16 x 5/8
6 1/2
9/32 x 5/8 at Root
7/32 x 11/16
Marquardt S-2
Spars - Soft but stringy balsa
8 1/2
3
48
6
Laminated Prop 18 1/2 Dia 30" Pitch
9
Wt. 4.25 oz
Power 16-18 Str 1/4 Dunlop 48" Long White Tensioner
+6°
8
16 1/2
4
+3°
Slight down & Right Treewheel
1/8 sq. Rock Hard
Very stable, long motor run, High climb to right. Tight right glide circles.
2
4
F. Zaic
Pop-Up Stab
3/16 Dowel
Wire clip holds dowel in groove
Plywood Plate
instead of wire clip on large models
WAKEFIELD
J. Kiener Van Nuys, Calif.

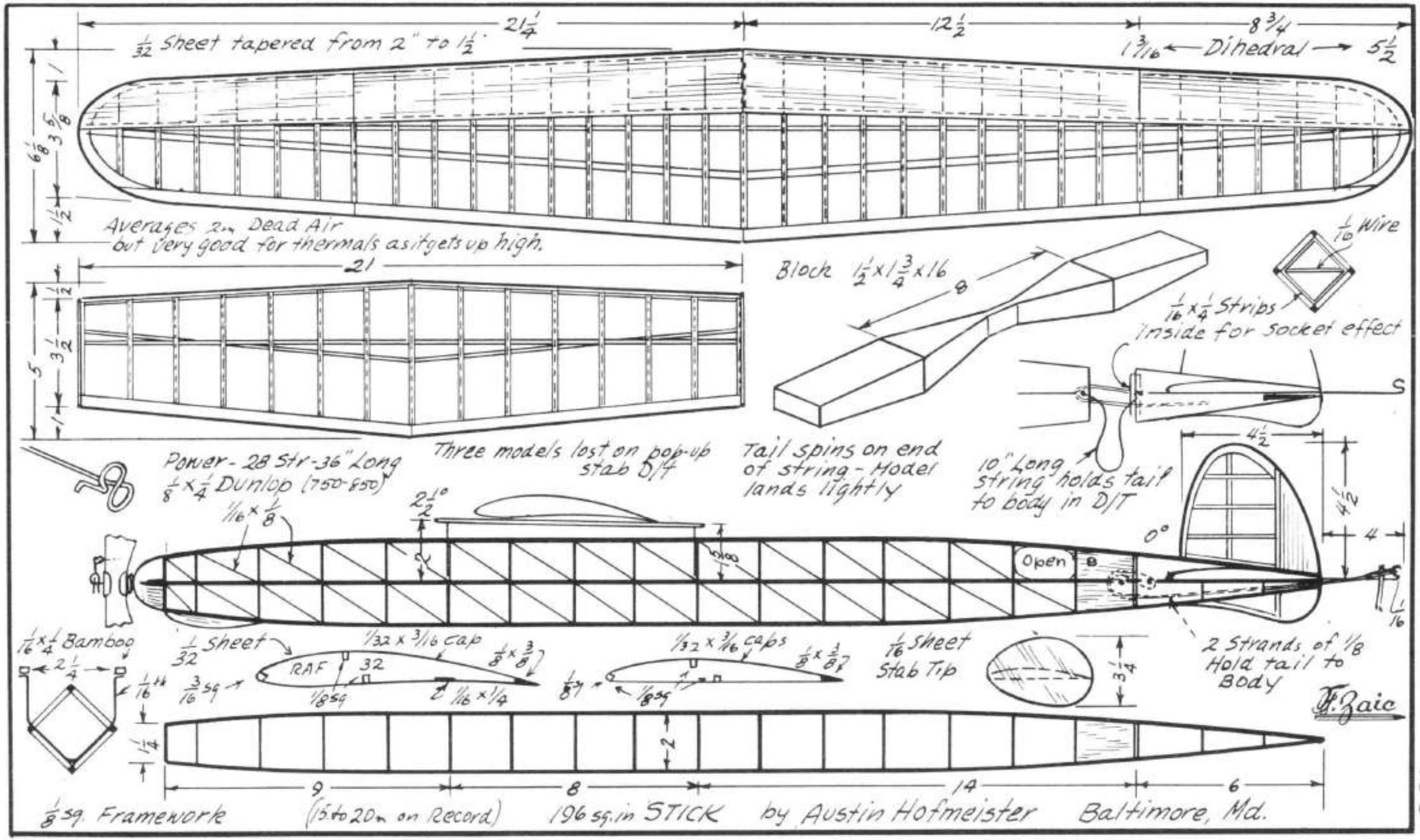

String
Rubber
Pivot & Stop
Trigger for operating stab. incidence on Horton model
-2°
Climb
0°
Glide
Slotted plate
Released & Stop

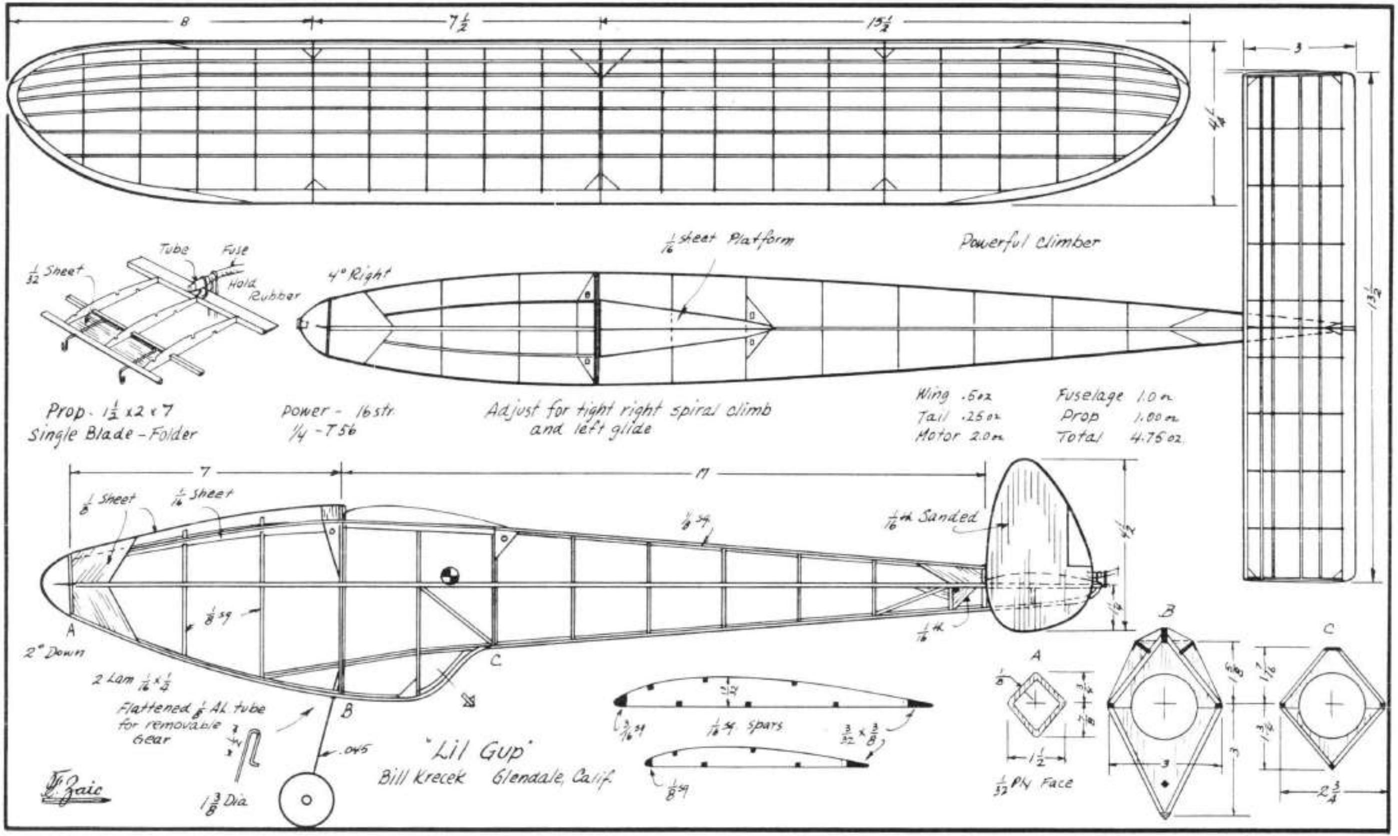


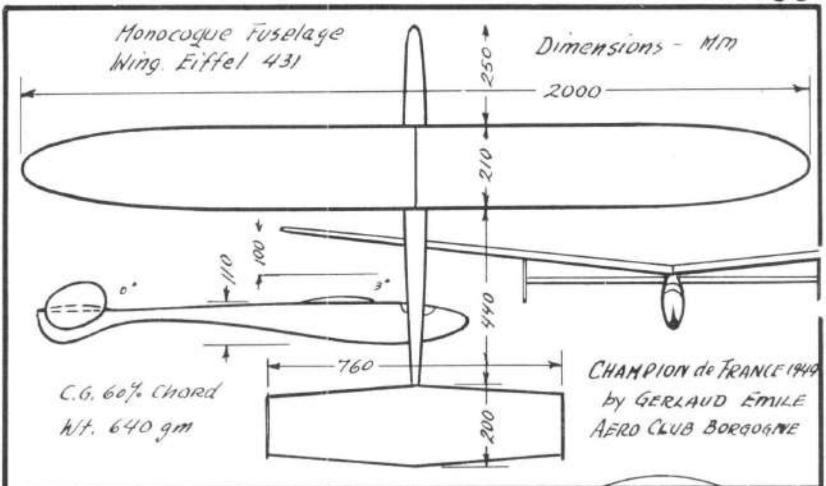
11.5
22
11.5
5
Wing 218 sq. in
Stab 75 sq. in.
4
3/4
1 3/4
1/8 sq.
1/8 x 1/4
1/16 x 1/8 Spars
RAF 32
1/16 Lt. Ribs
18 1/2
4
- WAKEFIELD -
by Jim Horton
Baltimore
Md.
9
3/4
Block
1 1/2 x 1 3/4 x 18
1/8 Sheet
Wing Mounts
3/32 sq.
1/8 sq.
1/8 x 1/4
Clark Y
1/16 Lt. Ribs
4
Large
Right
turn
climb
& Glide
Stab
-2° Climb
0° Glide
Power
28 Str. 1/8 x 1/4 Dunlop
56" Long-Corded
Wing .95 oz
Stab .36
Fuse.& Fins 1.40
Prop Assy 1.24
Rubber 4.20
Total 8.15
F. Zaic
5 1/4
3/4
4°
2
C.G.
1 1/2
2.6
6
2
1/8 Fill-in
2
FUSELAGE: 1/8 sq Balsa
Use Natural Strip Curves
3
16
16
13 1/2
4
3° Down
1° Right
C.G. of Model at C.G. of Rubber
2.8
1 1/2
Replacable Strut
1/8 x 1/4 Med. Balsa
Strut Socket
1 1/2
1/8 sq.
1/8 x 1/4

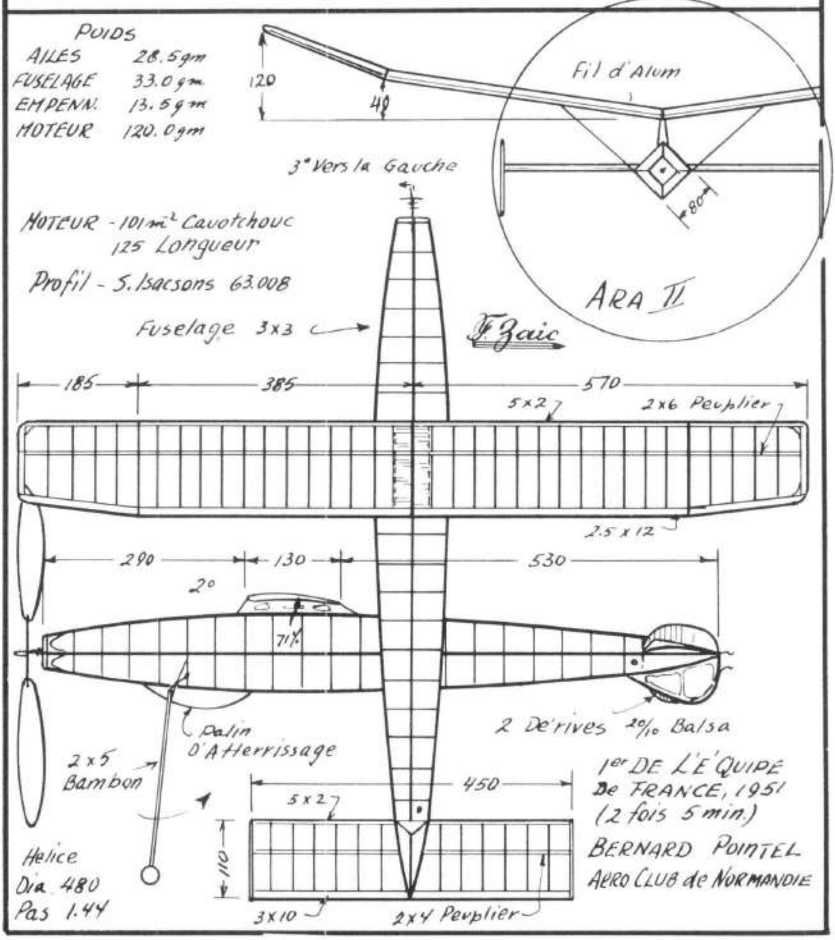


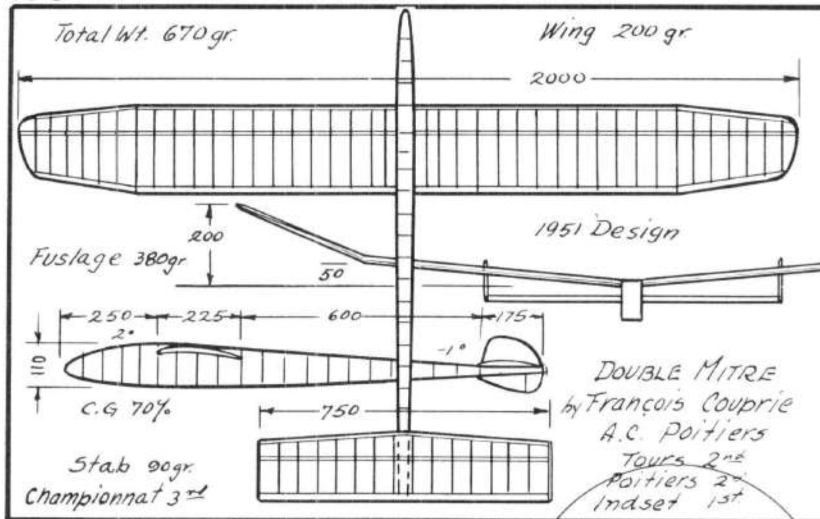
"51" UNLIMITED RUBBER by STUART SAVAGE

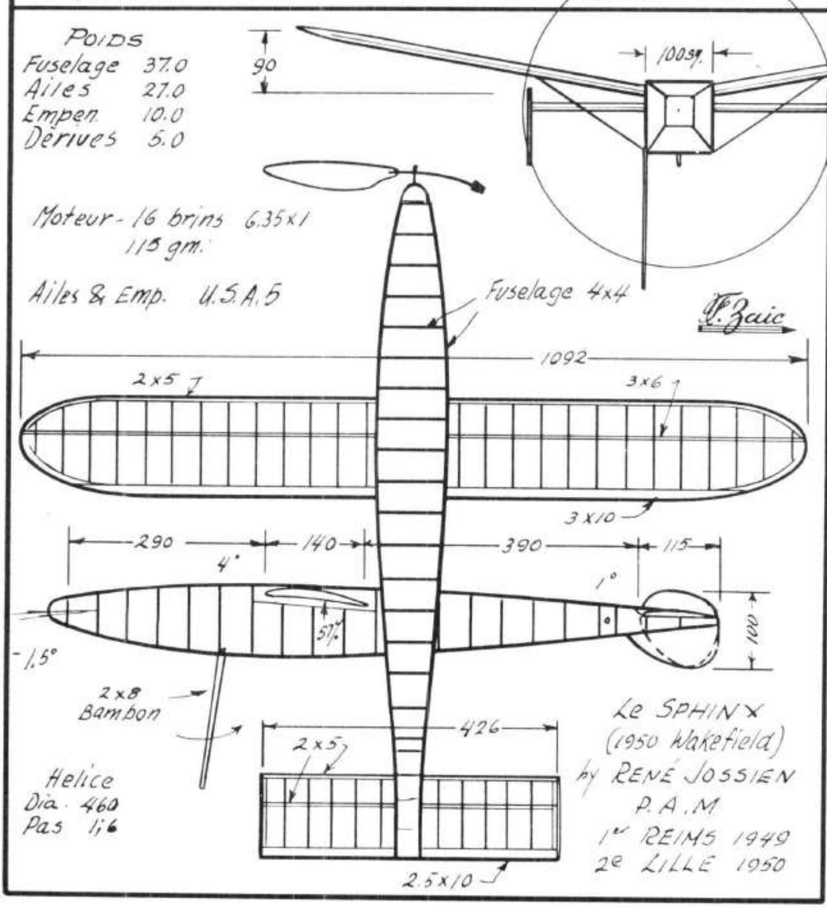

21 1/4
12 1/2
8 3/4
1/32 Sheet tapered from 2" to 1 1/2"
1 3/16 ← Dihedral → 5 1/2
6 1/8
3 5/8
1 1/2
Averages 2m Dead Air
but very good for thermals as it gets up high.
21
1/2
5
3 1/2
1
Block 1 1/2 x 1 3/4 x 16
8
1/16 Wire
1/16 x 1/4 Strips
Inside for socket effect
S
Power - 28 Str - 36" Long
1/8 x 1/4 Dunlop (750-850)
Three models lost on pop-up stab D/T
Tail spins on end of string - Model lands lightly
10" Long string holds tail to body in D/T
4 1/2
4 1/2
4
1/16 x 1/8
2 1/2°
0°
2
Open
1/16 x 1/4 Bamboo
2 1/4
1/16 sq
1/32 Sheet
1/32 x 3/16 cap
RAF 32
1/8 x 3/8
3/16 sq
1/8 sq
1/16 x 1/4
1/32 x 3/16 caps
1/8 x 3/8
1/8
1/8 sq
1/16 Sheet
Stab Tip
3 1/4
2 Strands of 1/8
Hold tail to
Body
1/16
F. Zaic
1 1/4
2
9
8
14
6
1/8 sq. Framework
(15 to 20m on Record)
196 sq. in STICK
by Austin Hofmeister
Baltimore, Md.

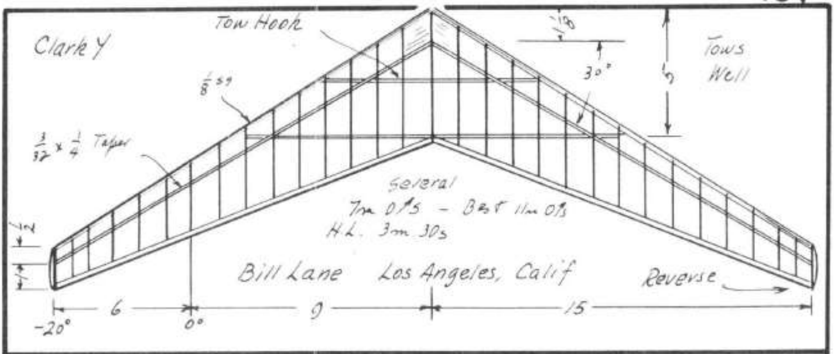

"Lil Gup"
Bill Krecek Glendale, Calif.
Powerful climber
1/16 sheet Platform
4° Right
Tube
Fuse
Hold Rubber
1/32 Sheet
Prop. 1 1/2 x 2 x 7
Single Blade - Folder
Power - 16 str.
1/4 - T56
Adjust for tight right spiral climb
and left glide
Wing .5 oz
Tail .25 oz
Motor 2.0 oz
Fuselage 1.0 oz
Prop 1.00 oz
Total 4.75 oz
1/8 Sheet
1/16 Sheet
1/8 sq
1/16 th Sanded
2" Down
2 Lam 1/16 x 1/4
Flattened 1/8 Al. tube
for removable
Gear
.045
1 3/8 Dia
3/16 sq
1/16 sq. spars
3/32 x 3/8
1/8 sq
1/32 Ply Face
A
B
C
Zaic

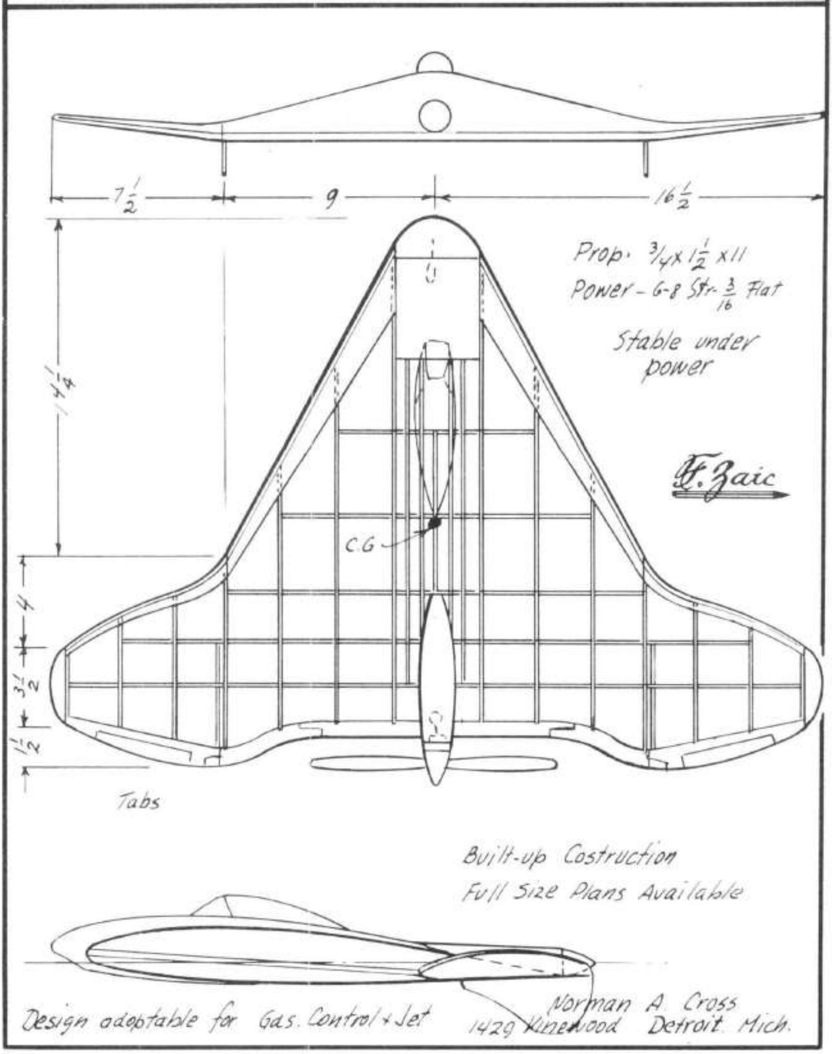

Monocoque Fuselage
Wing. Eiffel 431
Dimensions - Mm
2000
250
210
100
110
0°
3°
440
760
C.G. 60% Chord
Wt. 640 gm
200
CHAMPION de FRANCE 1949
by GERLAUD EMILE
AERO CLUB BORGOGNE

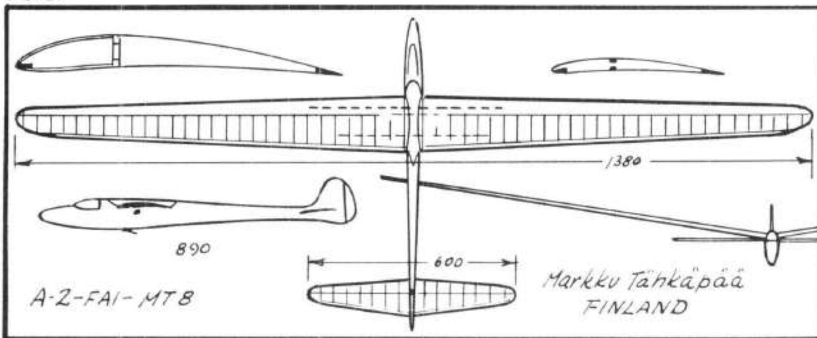

POIDS
AILES 28.5gm
FUSELAGE 33.0gm
EMPENN. 13.5gm
MOTEUR 120.0gm
120
40
Fil d'Alum
80
3° Vers la Gauche
MOTEUR - 101 m² Cavotchouc
125 Longueur
Profil - S. Isacsons 63.008
Fuselage 3x3
ARA II
F. Zaic
185
385
570
5x2
2x6 Peuplier
2.5 x 12
290
130
530
2°
71%
2 De'rives 20/10 Balsa
Palin
D'Atterrissage
2x5
Bambon
450
5x2
110
3x10
2x4 Peuplier
1er DE L'E'QUIPE
De FRANCE, 1951
(2 fois 5 min.)
BERNARD POINTEL
AERO CLUB de NORMANDIE
Helice
Dia 480
Pas 1.44

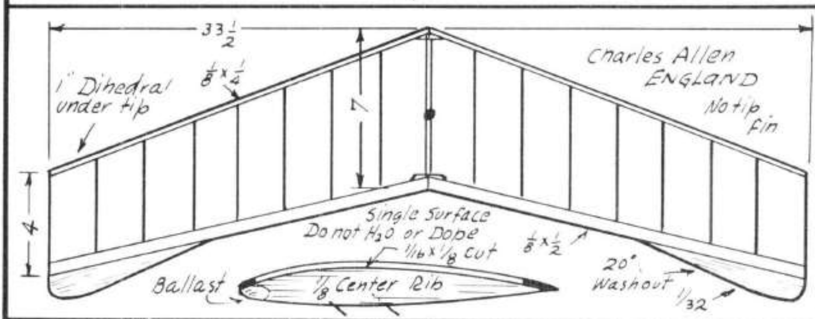

Total Wt. 670 gr.
Wing 200 gr.
2000
200
1951 Design
Fuslage 380gr.
50
250
225
600
175
2°
-1°
110
C.G 70%
750
DOUBLE MITRE
by François Couprie
A.C. Poitiers
Tours 2nd
Poitiers 2nd
Indset 1st
Stab 90gr.
Championnat 3rd

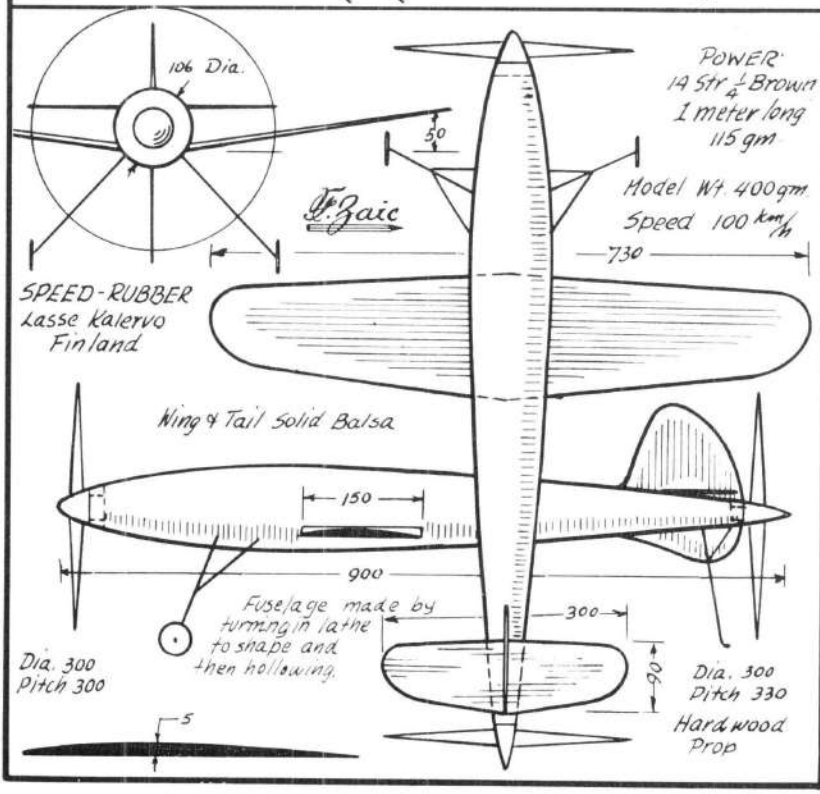

POIDS
Fuselage 37.0
Ailes 27.0
Empen. 10.0
Dérives 5.0
90
100 sq.
Moteur - 16 brins 6.35×1
115 gm.
Ailes & Emp. U.S.A.5
Fuselage 4×4
F. Zaic
1092
2×5
3×6
3×10
290
140
390
115
4°
1°
57%
100
-1.5°
2×8
Bambon
426
2×5
Helice
Dia. 460
Pas 1,6
LE SPHINX
(1950 Wakefield)
by RENÉ JOSSIEN
P.A.M
1er REIMS 1949
2e LILLE 1950
2.5×10

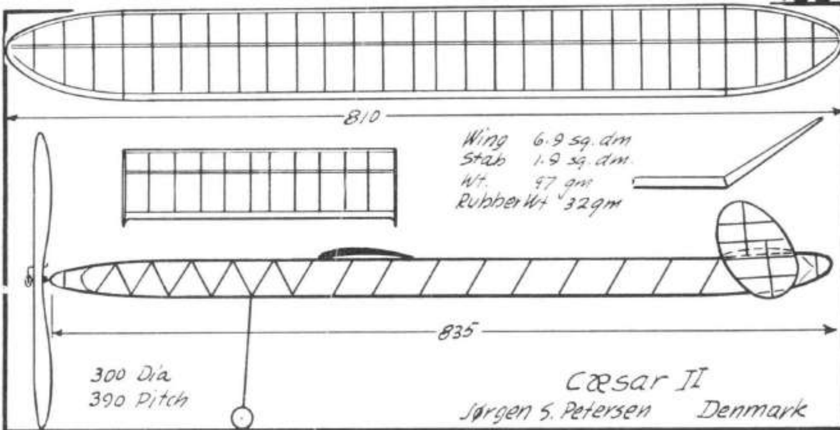

Clark Y
Tow Hook
1/8 sq
3/32 x 1/4 Taper
30°
Tows Well
Several
H.L. 3m 30s
Bill Lane Los Angeles, Calif
Reverse
6
9
15
-20°
0°

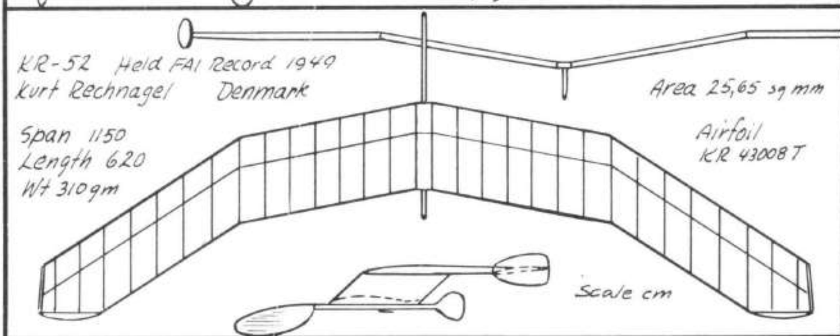

7 1/2
9
16 1/2
14 1/4
Prop. 3/4 x 1 1/2 x 11
Power - 6-8 Str. 3/16 Flat
Stable under power
F. Zaic
C.G
4
3 1/2
1 1/2
Tabs
Built-up Costruction
Full Size Plans Available
Design adoptable for Gas. Control + Jet
Norman A. Cross
1429 Pinewood Detroit. Mich.

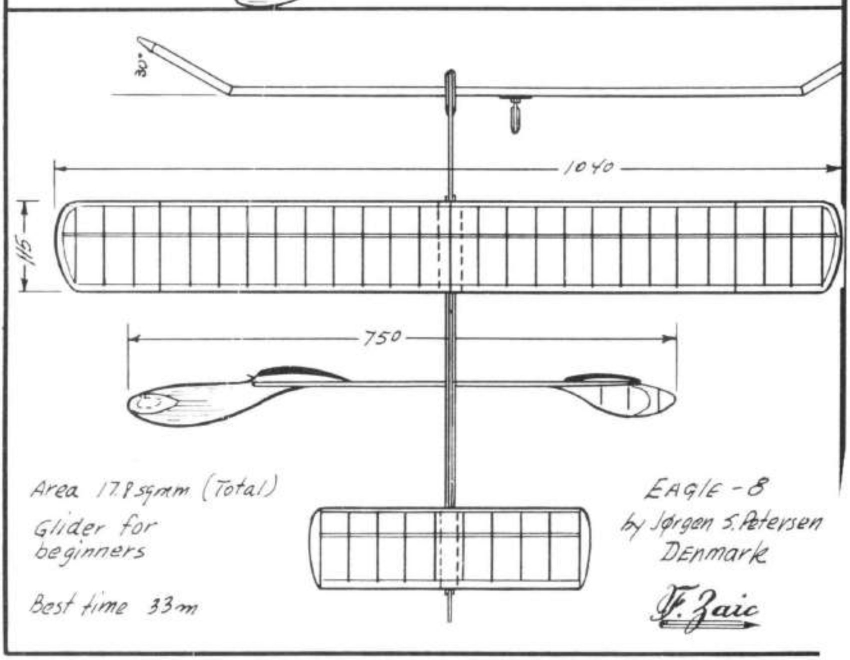

1380
890
600
A-2-FAI-MT8
Markku Tähkäpää
FINLAND

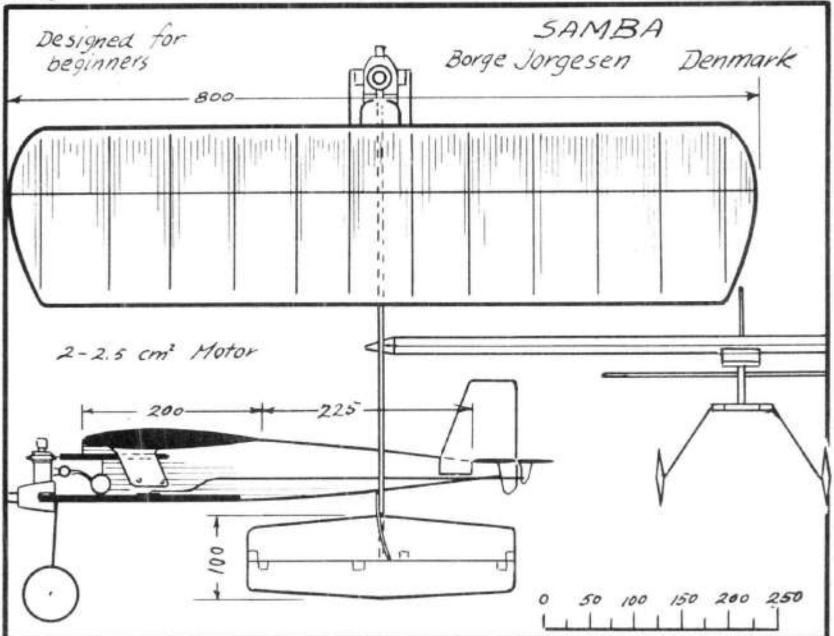

33 1/2
Charles Allen
ENGLAND
No tip fin
1" Dihedral under tip
1/8 x 1/4
7
4
Single Surface
Do not H2O or Dope
1/16 x 1/8 cut
1/8 x 1/2
20° Washout
1/32
Ballast
1/8 Center Rib


106 Dia.
50
POWER
14 Str 1/4 Brown
1 meter long
115 gm
Model Wt. 400 gm
Speed 100 km/h
730
SPEED-RUBBER
Lasse Kalervo
Finland
Wing & Tail Solid Balsa
150
900
Fuselage made by turning in lathe to shape and then hollowing.
300
90
Dia. 300
Pitch 300
Dia. 300
Pitch 330
Hardwood Prop
5

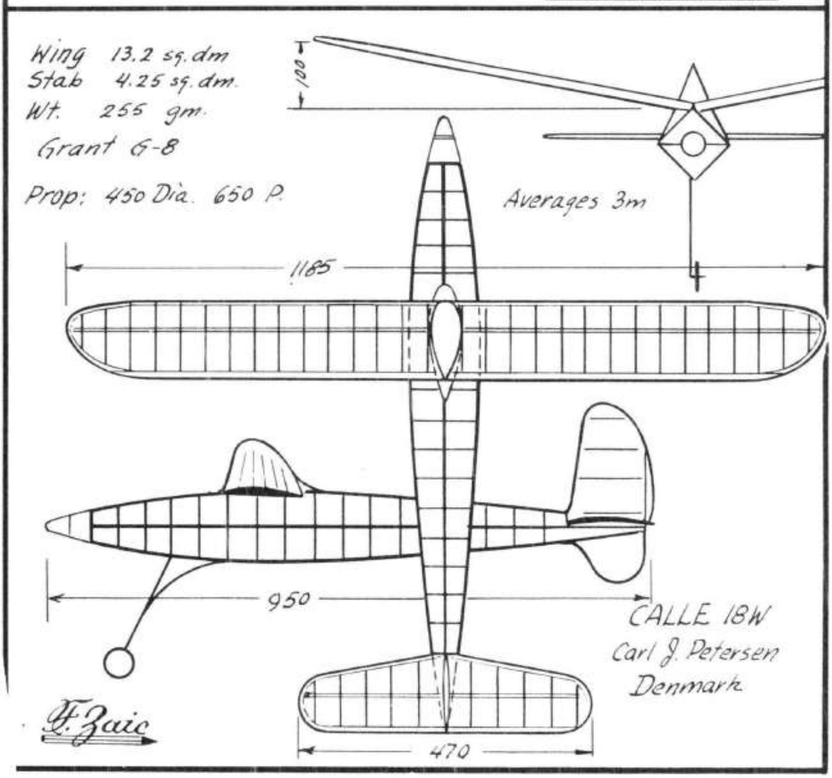

810
Wing 6.9 sq. dm
Stab 1.9 sq. dm.
Wt. 97 gm
Rubber Wt 32gm
835
300 Dia
390 Pitch
Cæsar II
Jørgen S. Petersen Denmark


KR-52 Held FAI Record 1949
Kurt Rechnagel Denmark
Area 25,65 sq mm
Span 1150
Length 620
Wt 310gm
Airfoil
KR 43008 T
Scale cm

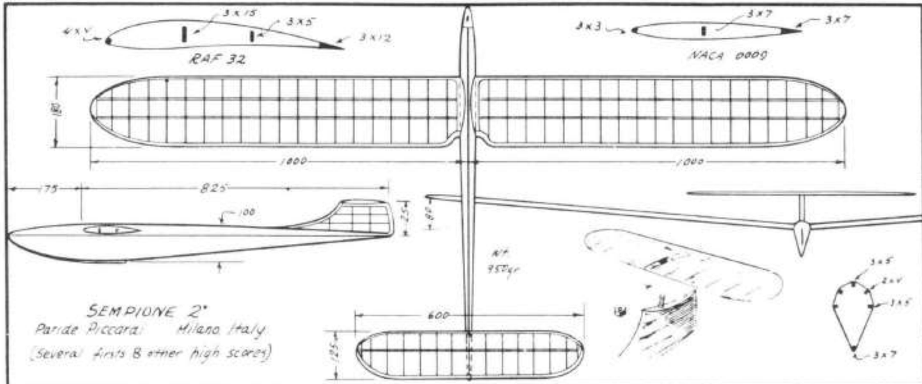

30°
1040
115
750
Area 17.8 sqmm (Total)
Glider for
beginners
Best time 33m
EAGLE - 8
by Jørgen S. Petersen
DENmark
F. Zaic

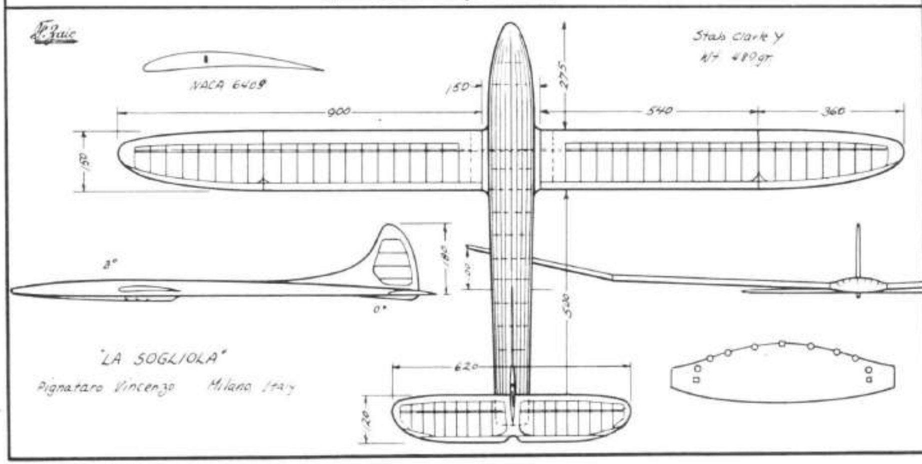


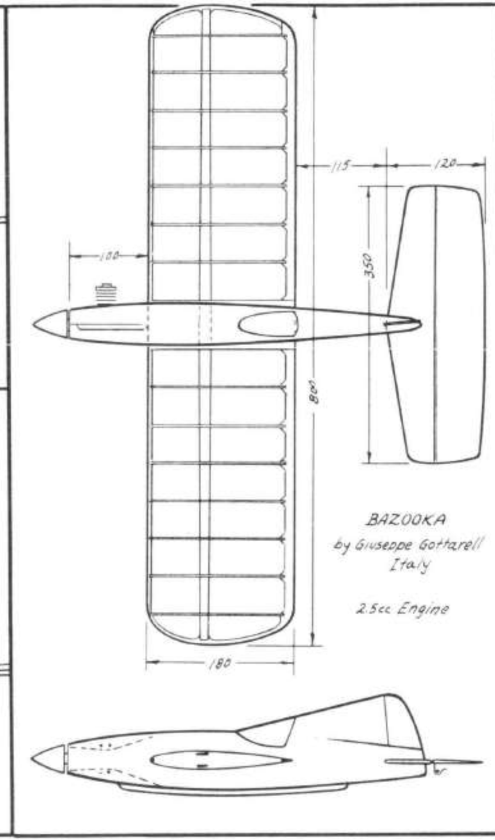
Designed for beginners
SAMBA
Borge Jorgesen Denmark
800
2-2.5 cm² Motor
200
225
100
0 50 100 150 200 250

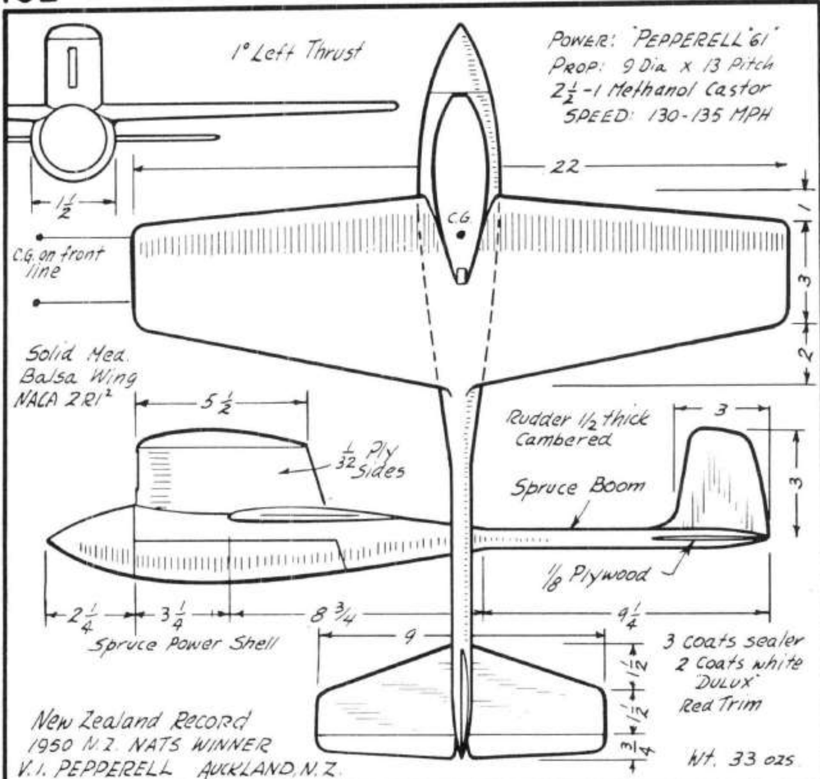


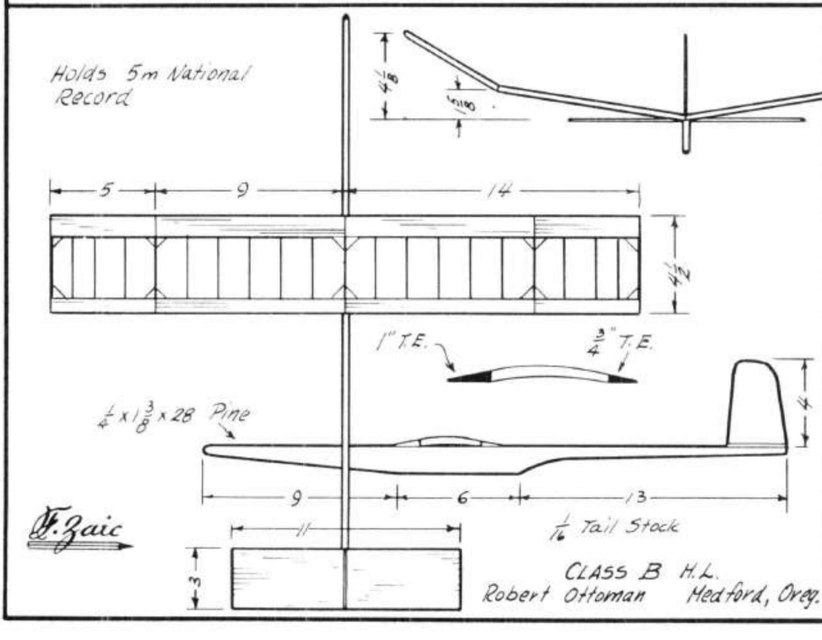
Wing 13.2 sq.dm
Stab 4.25 sq.dm.
Wt. 255 gm.
Grant G-8
Prop: 450 Dia. 650 P.
100
Averages 3m
1185
950
CALLE 18W
Carl J. Petersen
Denmark
470
F. Zaic

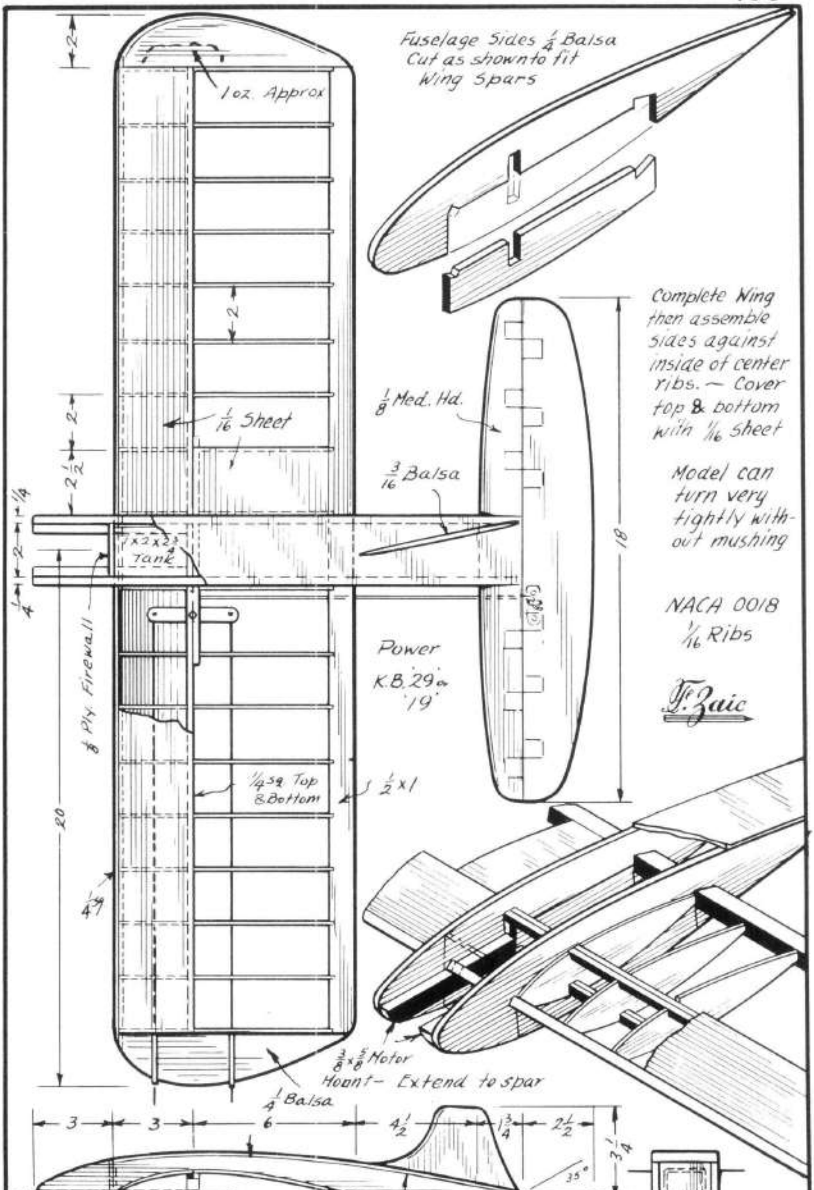

RAF 32
NACA 0009
SEMPIONE 2"
Paride Piccarai Milano Italy
(Several firsts & other high scores)
Wt 950 gr
1000
1000
825
600

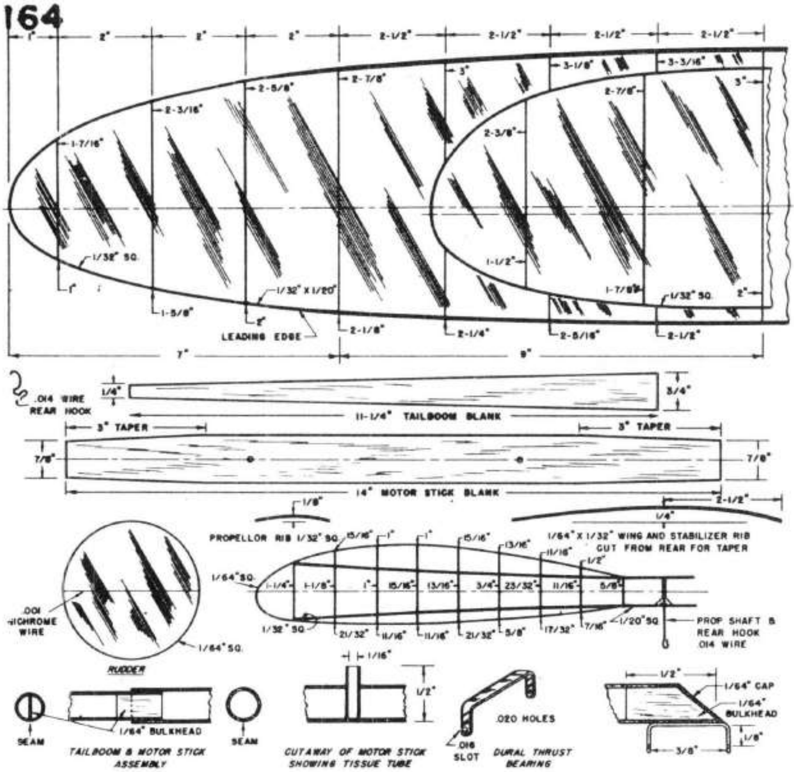

NACA 6409
Stab Clark Y
Wt 489 gr
900
540
360
620
"LA SOGLIOLA"
Pignataro Vincenzo Milano Italy


BAZOOKA
by Giuseppe Gottarell
Italy
2.5cc Engine
800
350
180

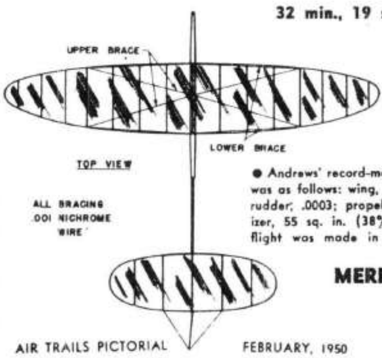

1° Left Thrust
POWER: "PEPPERELL 61"
PROP: 9 Dia x 13 Pitch
2½-1 Methanol Castor
SPEED: 130-135 MPH
22
1½
C.G.
C.G. on front line
1
3
2
Solid Med. Balsa Wing NACA 2R1²
5½
1/32 Ply Sides
Rudder ½ thick Cambered
3
3
Spruce Boom
1/8 Plywood
2¼
3¼
8¾
9¼
Spruce Power Shell
9
1½
1½
¾
3 coats sealer
2 Coats white "DULUX"
Red Trim
New Zealand Record
1950 N.Z. NATS WINNER
V.I. PEPPERELL AUCKLAND, N.Z.
Wt. 33 ozs

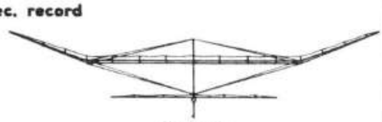

Holds 5m National Record
4⅛
5
9
14
4½
1" T.E.
¾" T.E.
¼ x 1⅜ x 28 Pine
4
9
6
13
1/16 Tail Stock
11
3
F. Zaic
CLASS B H.L.
Robert Ottoman Medford, Oreg.


Fuselage Sides 1/4 Balsa
Cut as shown to fit
Wing Spars
1 oz. Approx
Complete Wing
then assemble
sides against
inside of center
ribs. — Cover
top & bottom
with 1/16 sheet
1/8 Med. Hd.
1/16 Sheet
3/16 Balsa
Model can
turn very
tightly with-
out mushing
18
1x2x2 3/4
Tank
1/8 Ply. Firewall
NACA 0018
1/16 Ribs
Power
K.B. 29 or 19
F. Zaic
1/4 sq. Top
& Bottom
1/2 x 1
20
4 1/2
3/8 x 5/8 Motor
Mount — Extend to spar
1/4 Balsa
3
3
6
4 1/2
1 3/4
2 1/2
3 1/4
35°
35°
4 1/4
1/8 th
3
1/16 Sheet - Cross Grain
2" Dia
SCARED KITTEN
by BILL NETZEBAND, JOPLIN, MO.
7 1/2



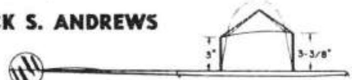
32 min., 19 sec. record

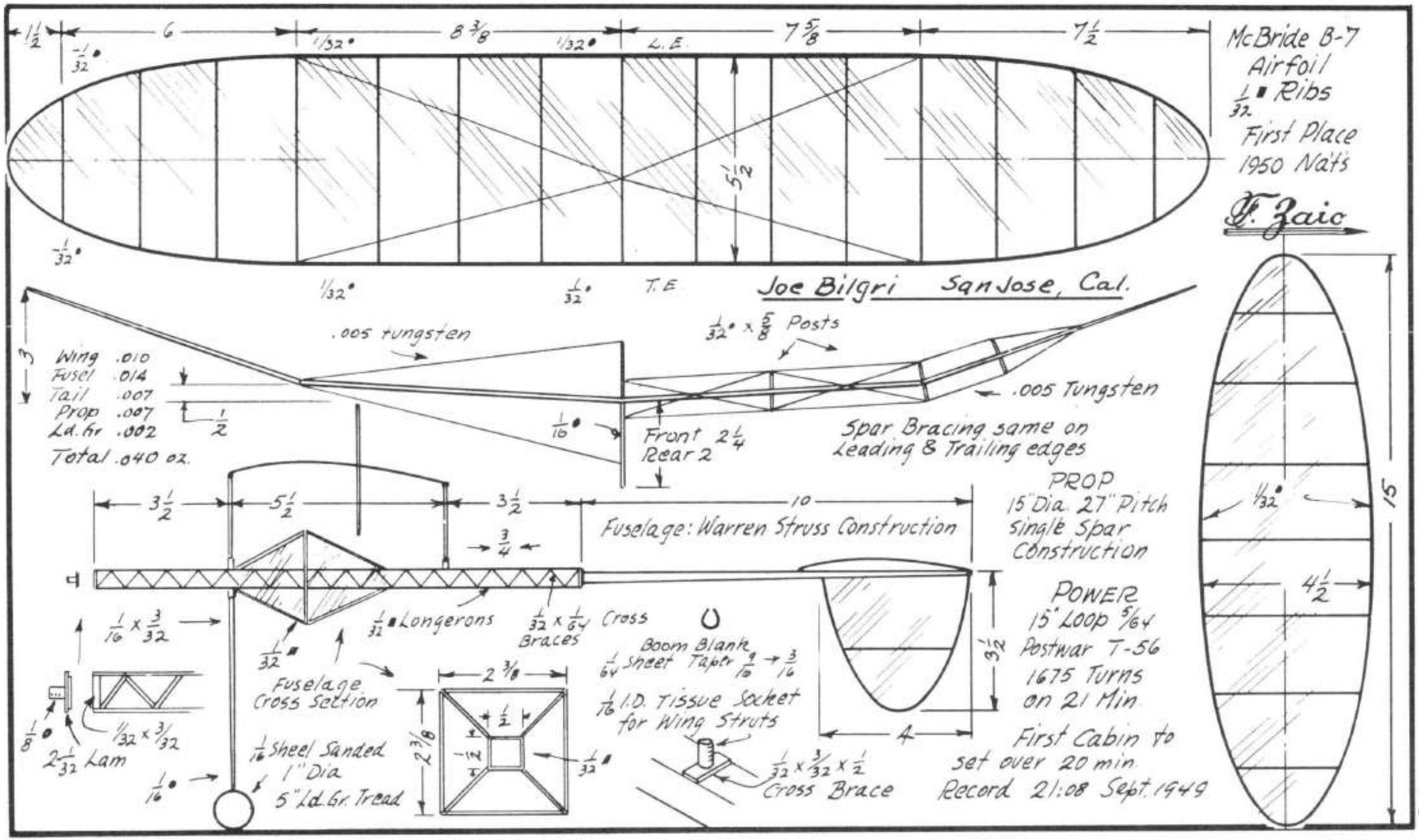


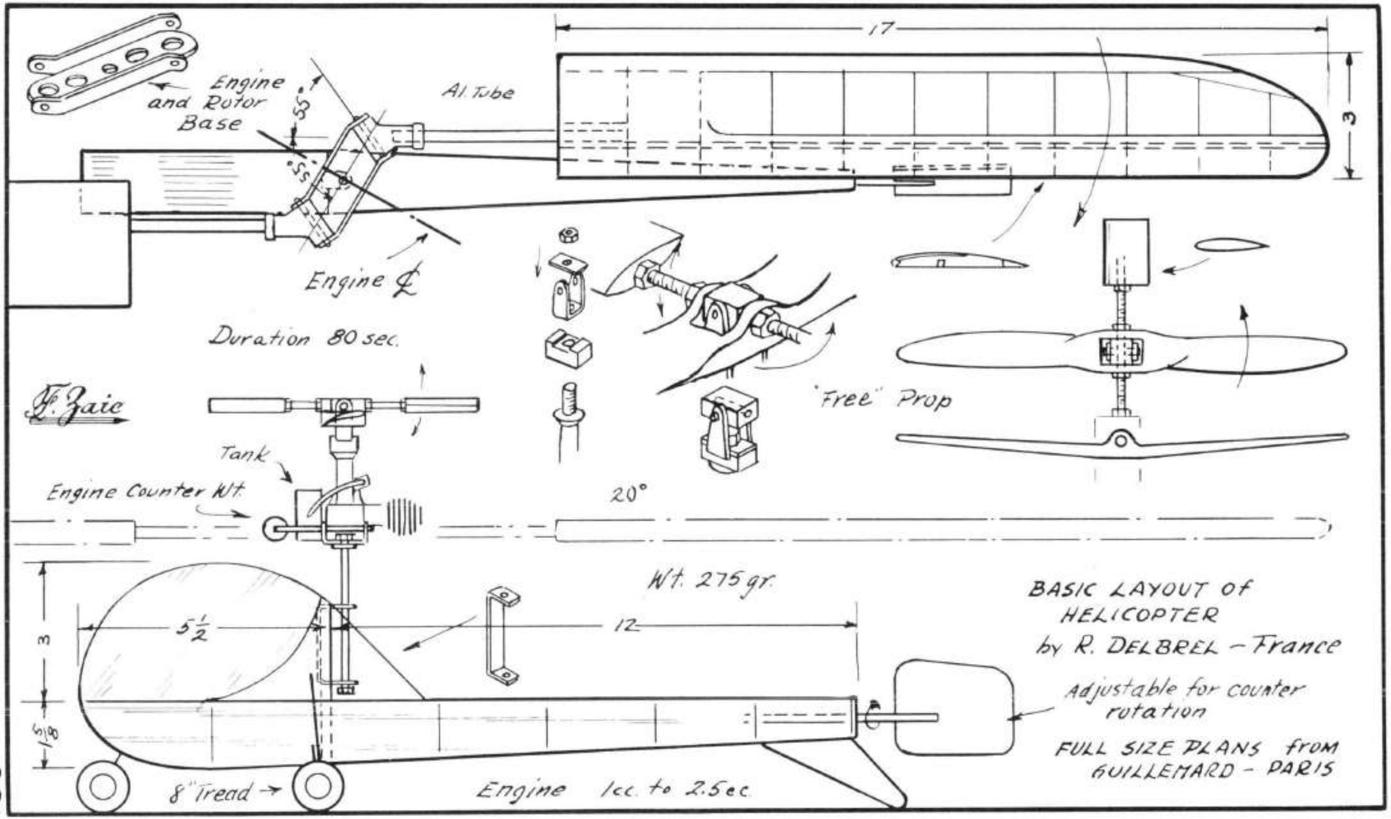


● Andrews' record-making aircraft weighed .0306 ozs. Weight of individual parts was as follows: wing, .0105; motor stick, .0090; tailboom, .0016; stabilizer, .0022; rudder, .0003; propeller, .0070. Areas of parts were wing, 147 sq. in.; stabilizer, 55 sq. in. (38% of wing); rudder, 7 sq. in. (4.9% of wing). Famous flight was made in air dock #5 at Navy's Lakehurst, N. J., air station.

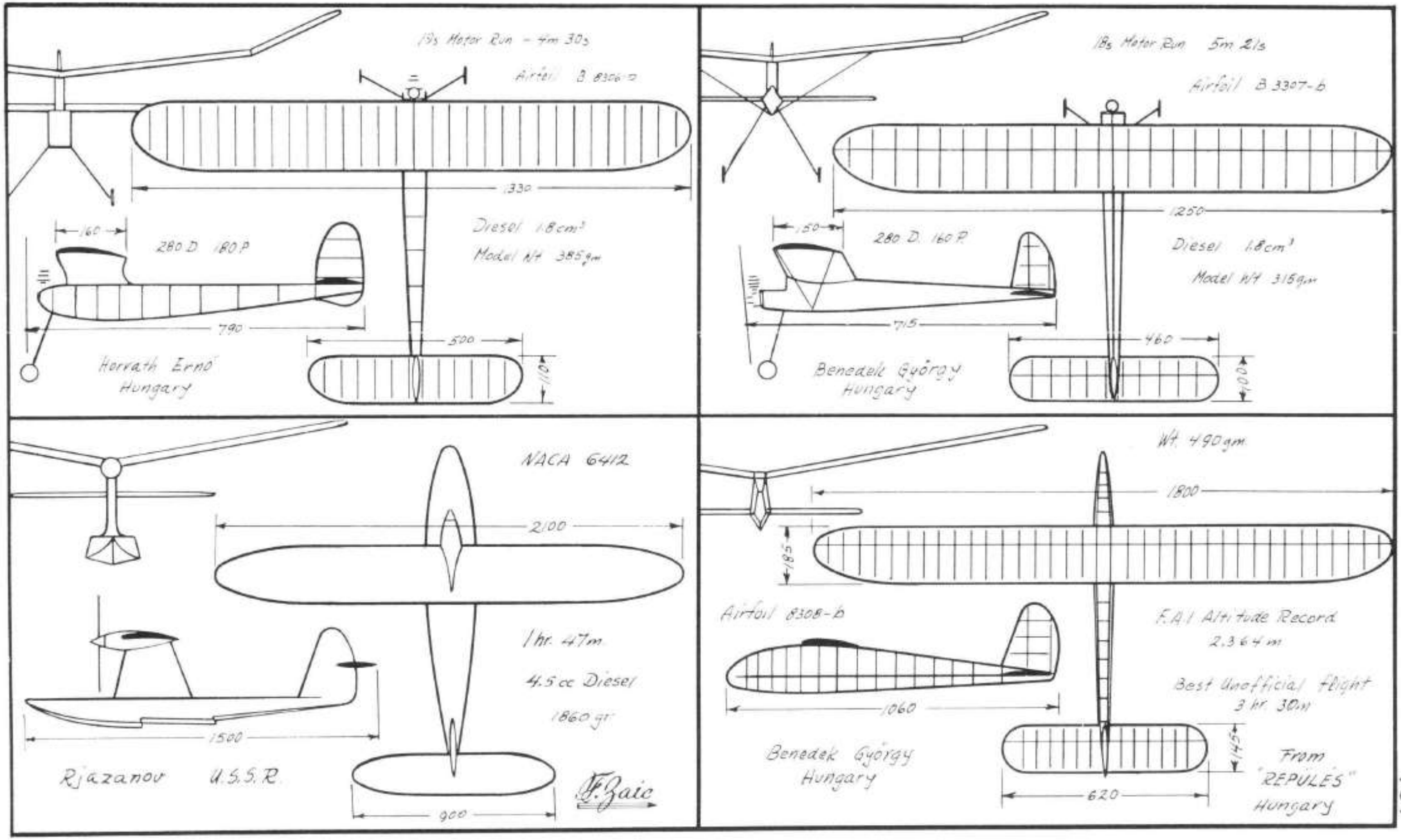
MERRICK S. ANDREWS

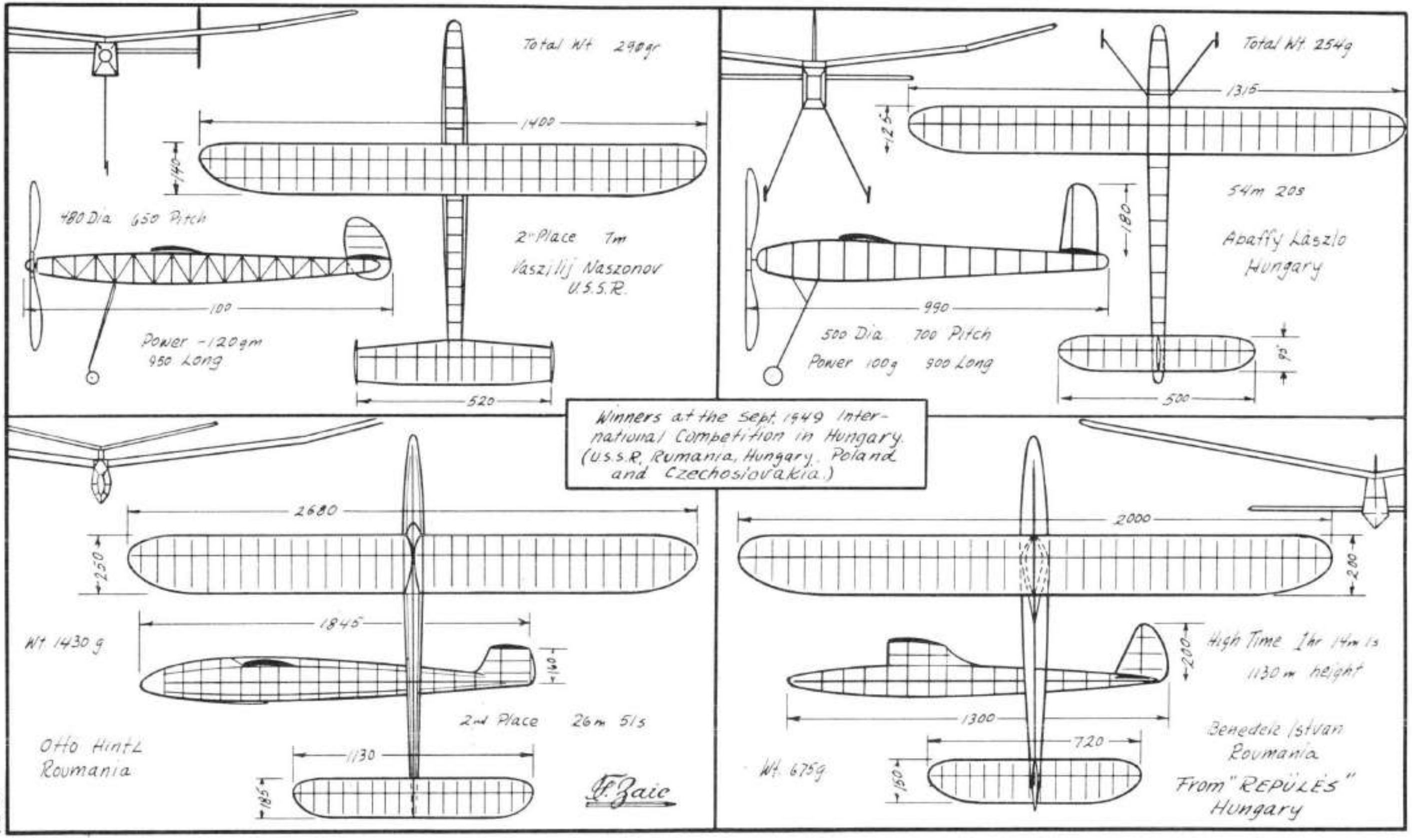



McBride B-7 Airfoil
1/32 ■ Ribs
First Place 1950 Nat's
F. Zaic
1 1/2
6
8 3/8
7 5/8
7 1/2
1/32 •
L.E.
T.E.
5 1/2
Joe Bilgri San Jose, Cal.
.005 tungsten
1/32 • x 5/8 Posts
.005 Tungsten
3
Wing .010
Fusel .014
Tail .007
Prop .007
Ld. Gr .002
Total .040 oz.
1/2
1/16 •
Front 2 1/4
Rear 2
Spar Bracing same on Leading & Trailing edges
PROP
15" Dia. 27" Pitch
single Spar Construction
3 1/2
5 1/2
3 1/2
10
3/4
Fuselage: Warren Struss Construction
1/16 x 3/32
1/32 ■ Longerons
1/32 x 1/64 Cross Braces
1/32 ■
Fuselage Cross Section
2 3/8
1/2
1/32 •
Boom Blank 1/64 Sheet Taper 9/16 → 3/16
1/16 I.D. Tissue Socket for Wing Struts
1/32 x 3/32 x 1/2 Cross Brace
3 1/2
4
POWER
15" Loop 5/64
Postwar T-56
1675 Turns on 21 Min
First Cabin to set over 20 min.
Record 21:08 Sept. 1949
15
4 1/2
1/32 •
1/8 •
2-1/32 Lam
1/32 x 3/32
1/16 •
1/16 Sheet Sanded 1" Dia
5" Ld. Gr. Tread

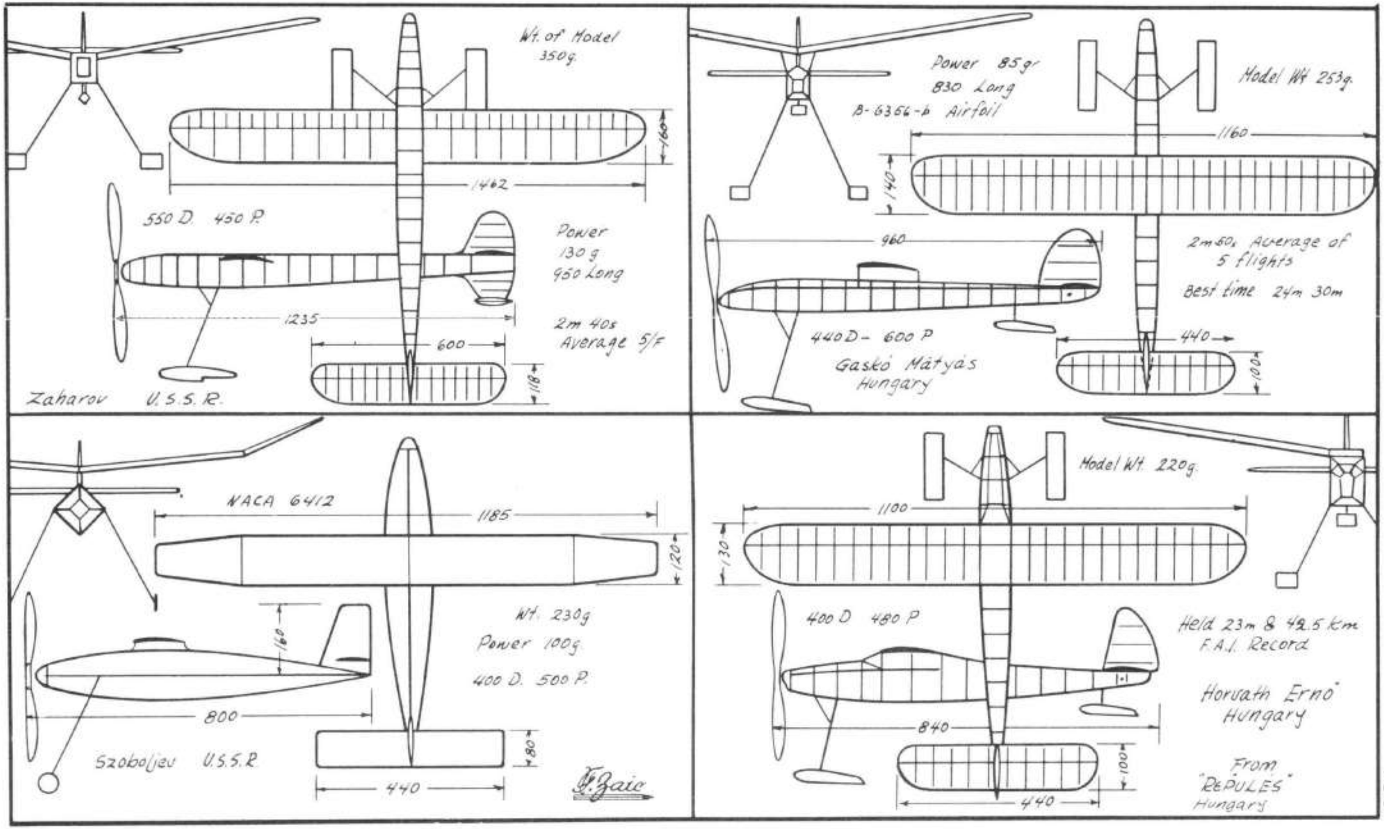


Engine and Rotor Base
55°
55°
Al. Tube
17
3
Engine ℄
Duration 80 sec.
F. Zaic
Tank
Engine Counter Wt.
"Free" Prop
20°
Wt. 275 gr.
5 1/2
12
3
1 5/8
8" Tread
Engine 1cc. to 2.5cc
BASIC LAYOUT OF HELICOPTER
by R. DELBREL - France
Adjustable for counter rotation
FULL SIZE PLANS from GUILLEMARD - PARIS

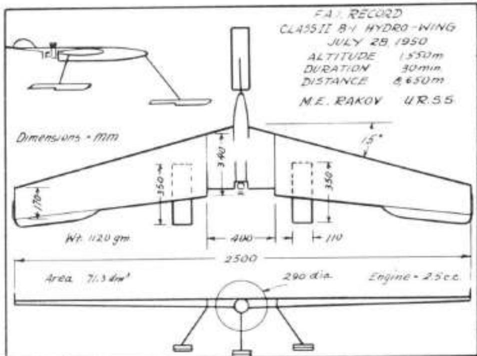

19s Motor Run – 4m 30s
Airfoil B 8306-a
1330
Diesel 1.8cm³
Model Wt 385gm
160
280 D. 180 P.
790
500
110
Horvath Ernö
Hungary
18s Motor Run 5m 21s
Airfoil B 3307-b
1250
150
280 D. 160 P.
Diesel 1.8cm³
Model Wt 315gm
715
460
100
Benedek György
Hungary
NACA 6412
2100
1 hr. 47m
4.5 cc Diesel
1860 gr
1500
900
Rjazanov U.S.S.R.
F. Zaic
Wt. 490gm
1800
185
Airfoil 8308-b
F.A.I. Altitude Record
2.364 m
Best Unofficial Flight
3 hr. 30m
1060
145
620
Benedek György
Hungary
From "REPÜLÉS" Hungary

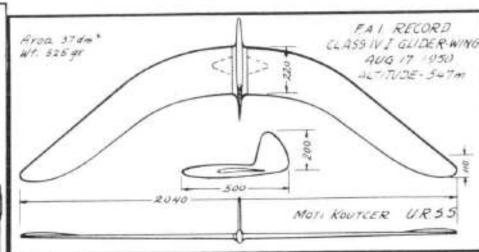


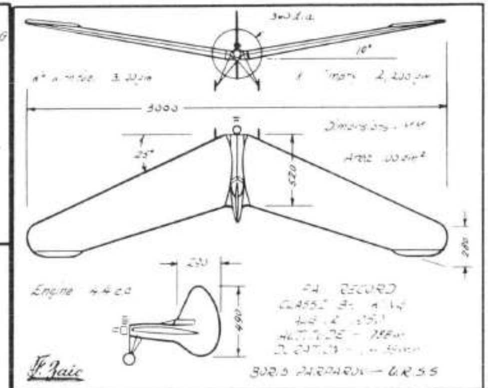
Winners at the Sept. 1949 International Competition in Hungary. (U.S.S.R., Rumania, Hungary, Poland and Czechoslovakia.)

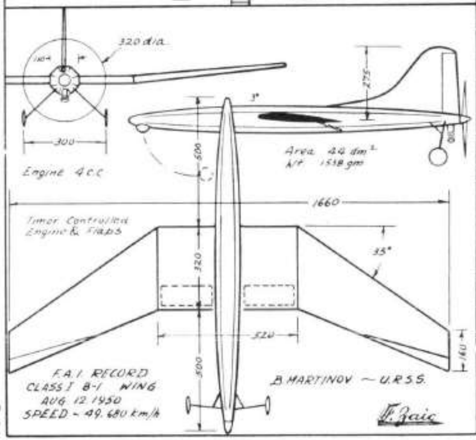


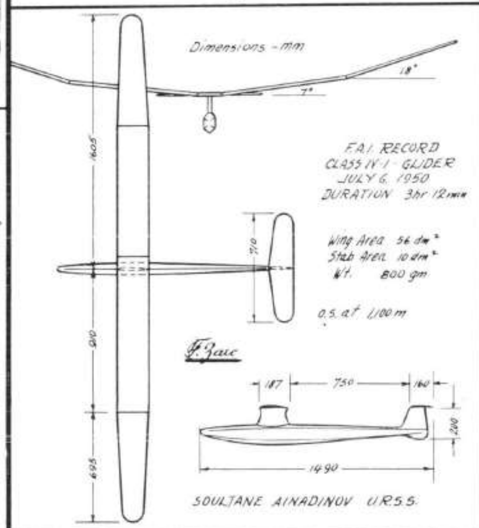
Wt. of Model 350g.
1462
160
550 D. 450 P.
Power 130 g 950 Long
1235
2m 40s Average 5/F
600
118
Zaharov U.S.S.R.
Power 85 gr 830 Long
B-6356-b Airfoil
Model Wt 253g.
1160
140
960
2m 50s Average of 5 flights
Best time 24m 30m
440D - 600 P
Gaskó Mátyás Hungary
440
100
NACA 6412
1185
120
160
Wt. 230g
Power 100g
400 D. 500 P.
800
80
Szoboljev U.S.S.R
440
F. Zaic
Model Wt. 220g.
1100
130
400 D 480 P
Held 23m & 42.5 km F.A.I. Record
Horvath Ernö Hungary
840
100
440
From "REPULES" Hungary

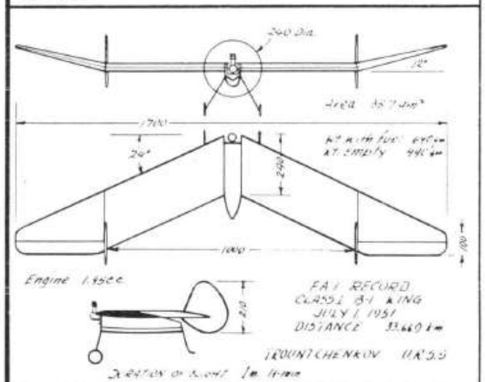

F.A.I. RECORD
CLASS II B-1 HYDRO-WING
JULY 28, 1950
ALTITUDE 1,550m
DURATION 30min
DISTANCE 8,650m
M.E. RAKOV U.R.S.S.
Dimensions - mm
15°
340
350
350
170
Wt. 1120 gm
400
110
2500
Area 71.3 dm²
290 dia
Engine - 2.5 c.c.

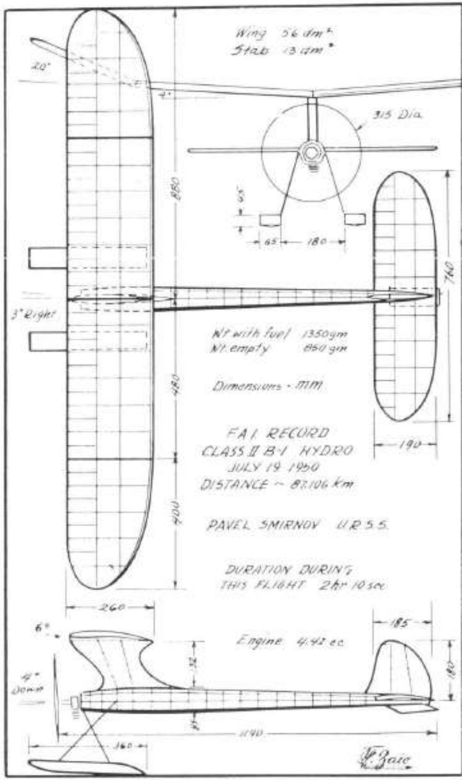

Area 37 dm²
Wt. 525 gr
F.A.I. RECORD
CLASS IV I GLIDER-WING
AUG 17 1950
ALTITUDE - 547m
220
200
110
500
2040
MOTI KOUTCER U.R.S.S.

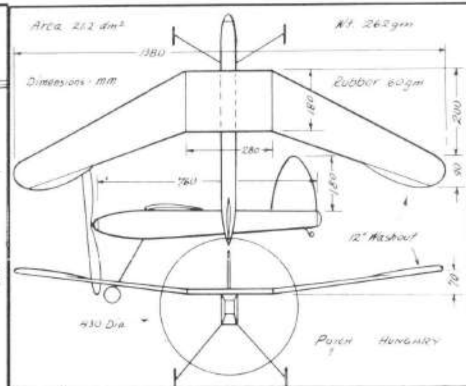

3° 10°
3000
25°
520
280
230
490
Engine 4.4 c.c.
F.Zaic

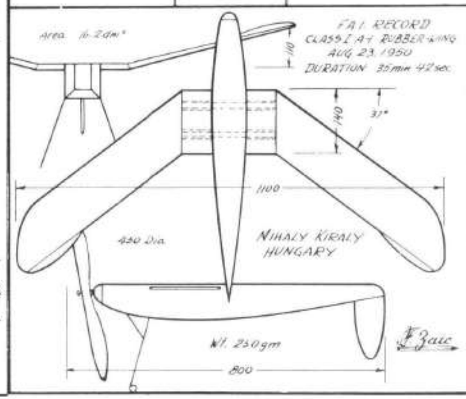

320 dia
275
3°
300
500
Area 44 dm²
Wt. 1538 gm
Engine 4 c.c.
1660
Timer Controlled Engine & Flaps
35°
320
520
160
500
F.A.I. RECORD
CLASS I B-1 WING
AUG. 12 1950
SPEED - 49.680 km/h
B. MARTINOV — U.R.S.S.
F.Zaic

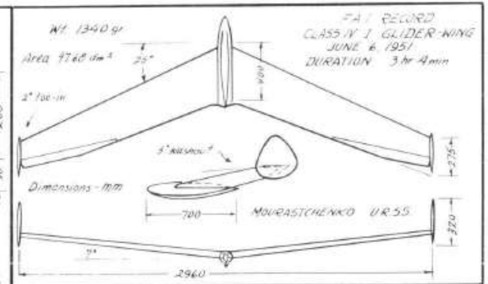

Dimensions - mm
18°
7°
1605
F.A.I. RECORD
CLASS IV-1 - GLIDER
JULY 6, 1950
DURATION 3hr 12min
710
Wing Area 56 dm²
Stab Area 10 dm²
Wt. 800 gm
0.S. at 1,100 m
910
F.Zaic
695
187
750
160
200
1490
SOULTANE AINADINOV U.R.S.S.

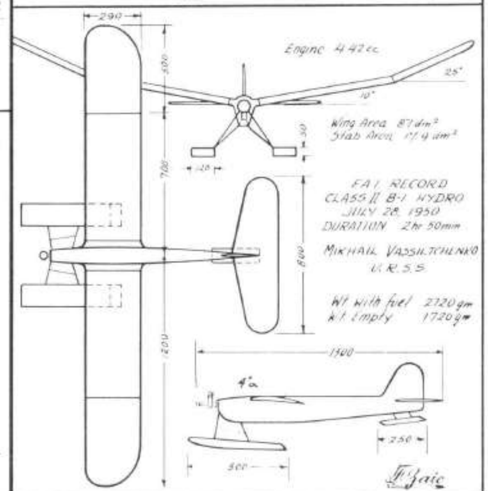

240 Dia.
12°
1700
24°
240
100
1000
Engine 1.45 c.c.
210
F.A.I. RECORD
CLASS I B-1 WING
JULY 1, 1951
DISTANCE 33.669 km
TROUNTCHENKOV U.R.S.S.

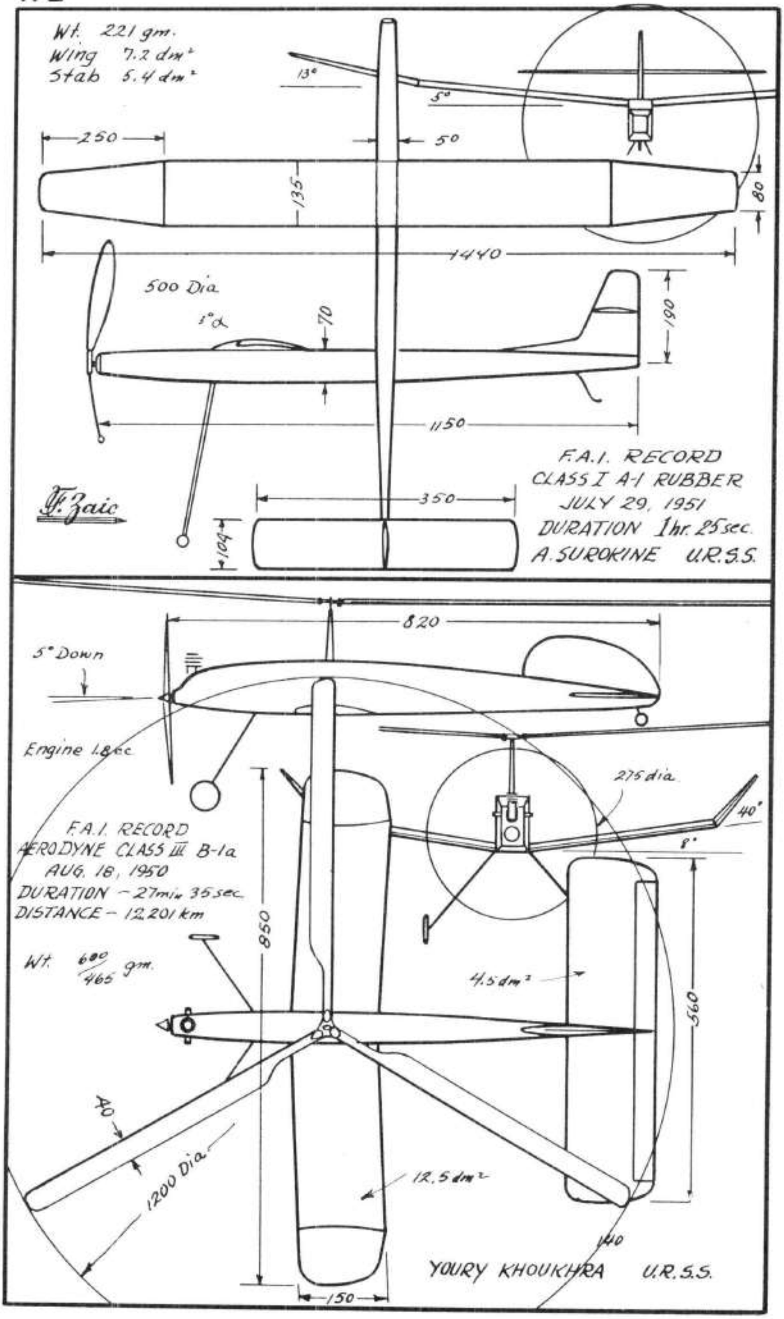

Wing 56 dm²
Stab 13 dm²
20°
2°
315 Dia.
880
65
180
760
3° Right
Wt. with fuel 1350 gm
Wt. empty 850 gm
Dimensions - mm
480
F.A.I. RECORD
CLASS II B-1 HYDRO
JULY 19 1950
DISTANCE ~ 87.106 Km
190
400
PAVEL SMIRNOV U.R.S.S.
DURATION DURING
THIS FLIGHT 2 hr 10 sec
260
185
6°
Engine 4.42 cc
32
180
4° Down
1190
360
F. Zaic

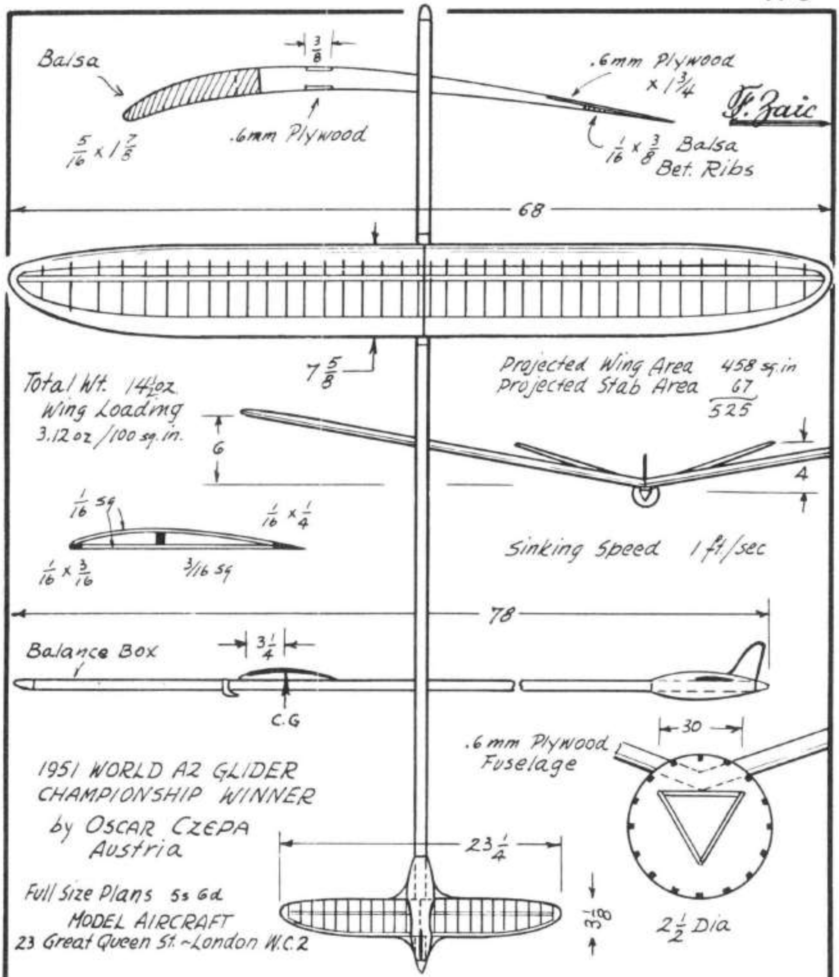

Area 21.2 dm²
Wt. 262 gm
1380
Dimensions - mm
Rubber 60 gm
180
200
280
760
180
90
12° Washout
70
430 Dia.
POICH HUNGARY


Area 16.2 dm²
F.A.I. RECORD
CLASS I A-1 RUBBER-WING
AUG 23, 1950
DURATION 35 min 42 sec
110
140
37°
1100
450 Dia.
MIHALY KIRALY
HUNGARY
Wt. 250 gm
800
F. Zaic


Wt. 1340 gr
F.A.I. RECORD
CLASS IV I GLIDER-WING
JUNE 6, 1951
DURATION 3 hr 4 min
Area 97.68 dm²
25°
400
2° toe-in
3° washout
275
Dimensions - mm
700
MOURASTCHENKO U.R.S.S.
220
7°
2960


290
Engine 4.42 cc
25°
300
10°
Wing Area 87 dm²
Stab Area 17.4 dm²
30
120
700
F.A.I. RECORD
CLASS II B-1 HYDRO
JULY 28, 1950
DURATION 2 hr 50 min
800
MIKHAIL VASSILTCHENKO
U.R.S.S.
Wt. with fuel 2720 gm
Wt. empty 1720 gm
1200
1300
4°
250
300
F. Zaic


Wt. 221 gm.
Wing 7.2 dm²
Stab 5.4 dm²
13°
5°
250
50
135
80
1440
500 Dia
1° α
70
190
1150
350
104
F. Zaic
F.A.I. RECORD
CLASS I A-1 RUBBER
JULY 29, 1951
DURATION 1hr. 25sec.
A. SUROKINE U.R.S.S.
820
5° Down
Engine 1.8cc
275 dia.
40°
8°
F.A.I. RECORD
AERODYNE CLASS III B-1a
AUG. 18, 1950
DURATION – 27min 35sec.
DISTANCE – 12.201 km
850
Wt. 600/465 gm.
4.5 dm²
560
40
1200 Dia
12.5 dm²
140
YOURY KHOUKHRA U.R.S.S.
150



UNORTHODOX to British eyes, the *Toothpick* is the latest model in a long series of designs based on practical experiment and a study of the theory of low speed aerodynamics. It is typical of what is known in Austria as the " Vienna School " of design.

Basically the main requirements of a good towline glider are :—

(i) It must have good line stability.
(ii) Adequate lateral stability.
(iii) Design proportioned to the best advantage for that particular class, with the emphasis on minimum sinking speed.

Line stability is achieved by virtually eliminating all side area in front of the wings, so that all the surfaces offering " keel " area are grouped at the tail end. Even the small nacelle giving the required fuselage cross-section is grouped around the tail, again with a certain fin effect.

Lateral stability is taken care of by using straight dihedral of 10 deg., which has been found quite adequate under all conditions. With the first two conditions satisfied the remainder of the design is based on arriving at the best possible arrangement to meet condition (iii).

Broadly speaking, the main requirements for a low sinking speed are high lift and low drag. The fuselage serves only as a bearer or supporting member for the wing and tail unit. Aerodynamically it is a nuisance and so to minimise this nuisance its wetted area and cross-section are reduced to the smallest possible figure. It could be argued that by using a very long fuselage we are defeating our own end (i.e., trying to reduce wetted area), but we need a long fuselage for two very important reasons. In the first place we have a fixed total area for the A/2 specification. On any conventional model the wing flies at its optimum attitude for best lift. The tailplane operates at a lower lift, or no lift at all if it is used as a pure stabiliser. Hence, with a fixed *total* area the best arrangement is to allocate as much as possible of this area to the wings.

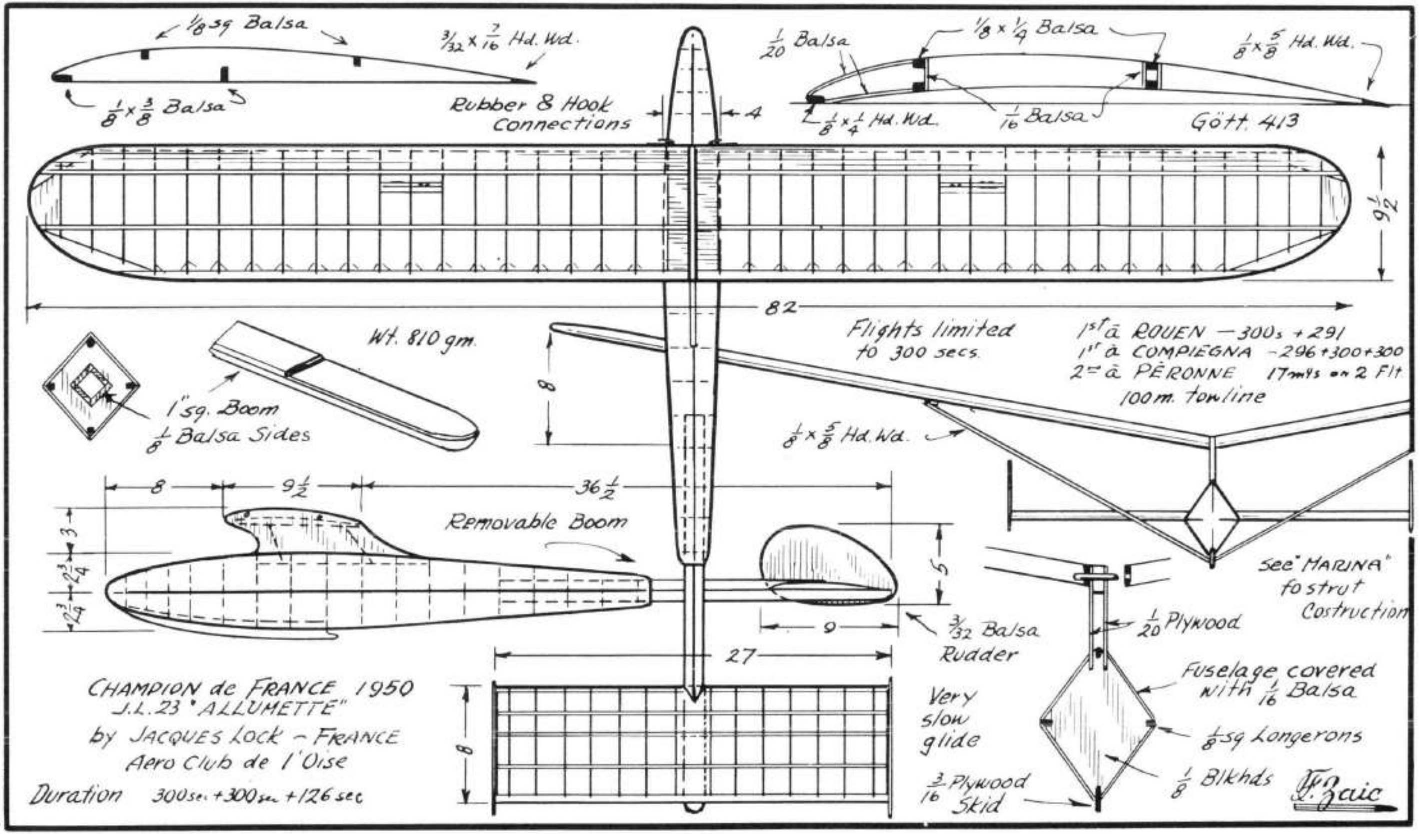
We have found it possible to reduce tailplane area to between one-eighth and one-seventh of the wing area, and still retain adequate longitudinal stability, provided we use a moment arm of between five and seven times the wing chord. Still keeping our fuselage cross-section small, we simply extended it aft of the wings for the required distance.

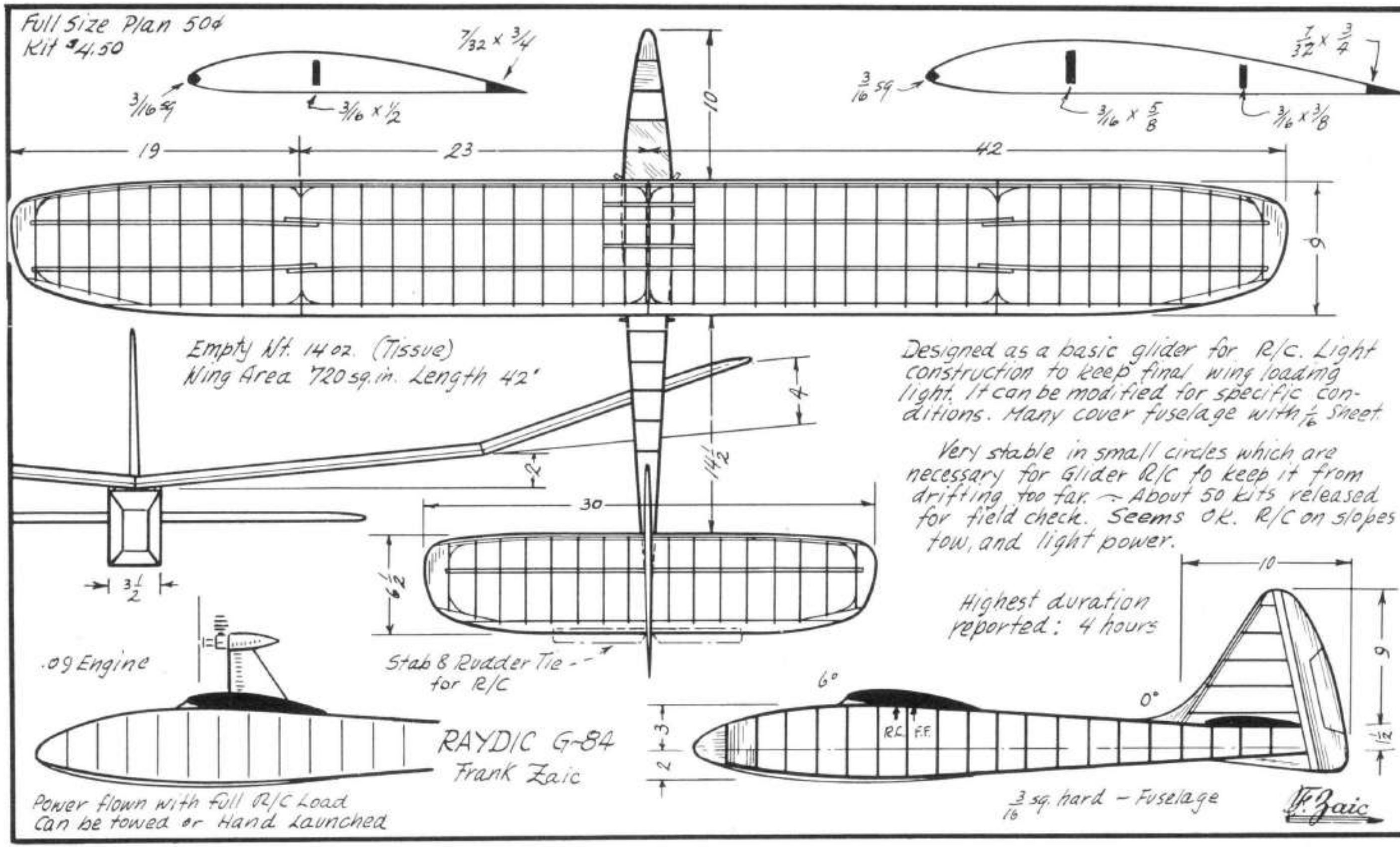
This long stick fuselage had to be made of ply. Balsa is very difficult to obtain in Austria and it is doubtful that a balsa fuselage of similar cross-section would be strong enough, in any case. But ply is relatively heavy and so to balance out the model within the permitted $14\frac{1}{2}$ oz. minimum total weight we simply extend the front part of the fuselage forward until we can get the required balance with only a small amount of ballast.

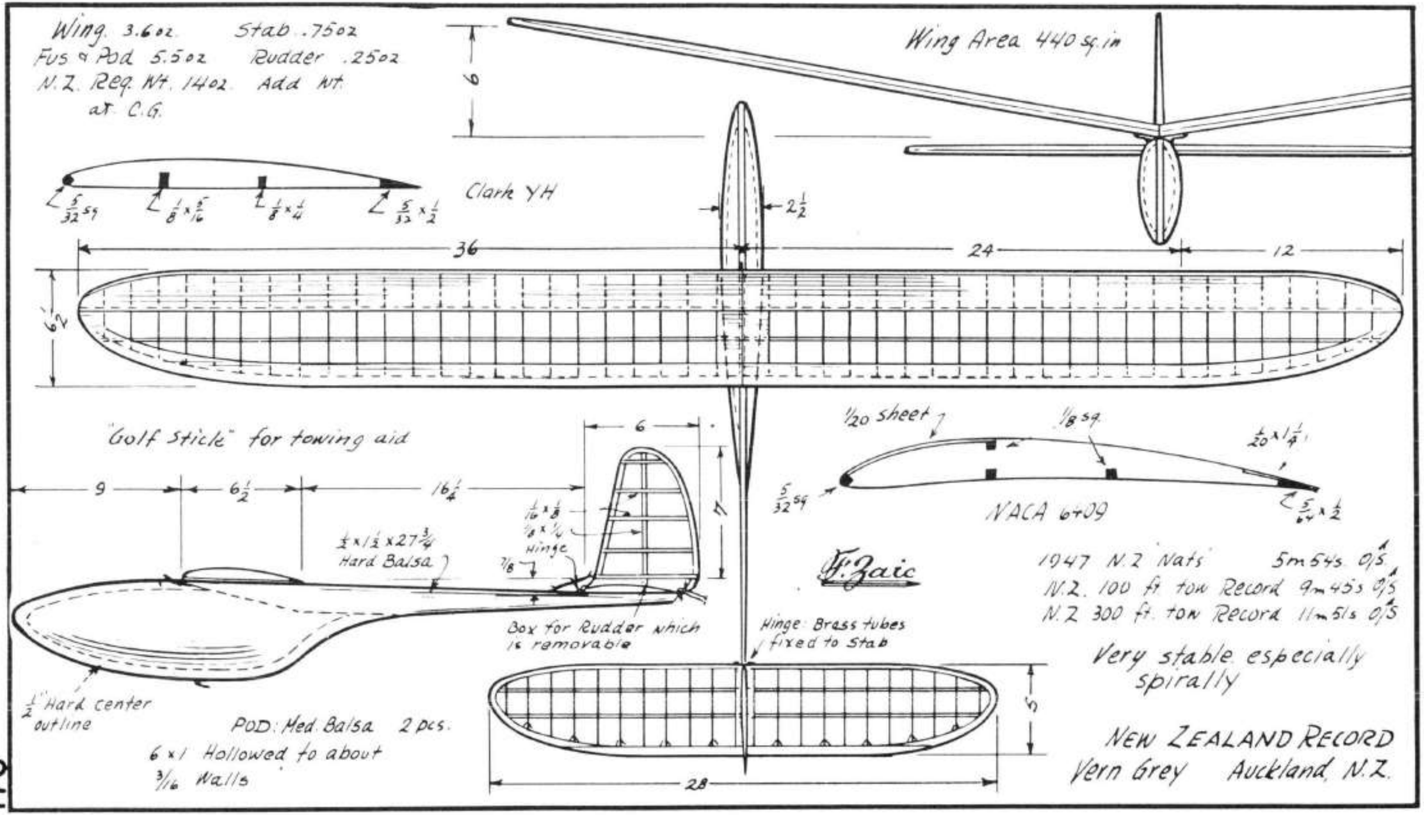
We thus have a very efficient set-up, with low drag and high lift already partially assured by the large wing area. The final factor is the aerofoil section. The particular section used was evolved after a long series of experiments and is one which we believe gives very nearly optimum performance for glider wings of all sizes. It has very high lift values with correspondingly low drag.

Construction of the model should not present undue difficulties to an experienced builder, although the materials used are somewhat different from standard

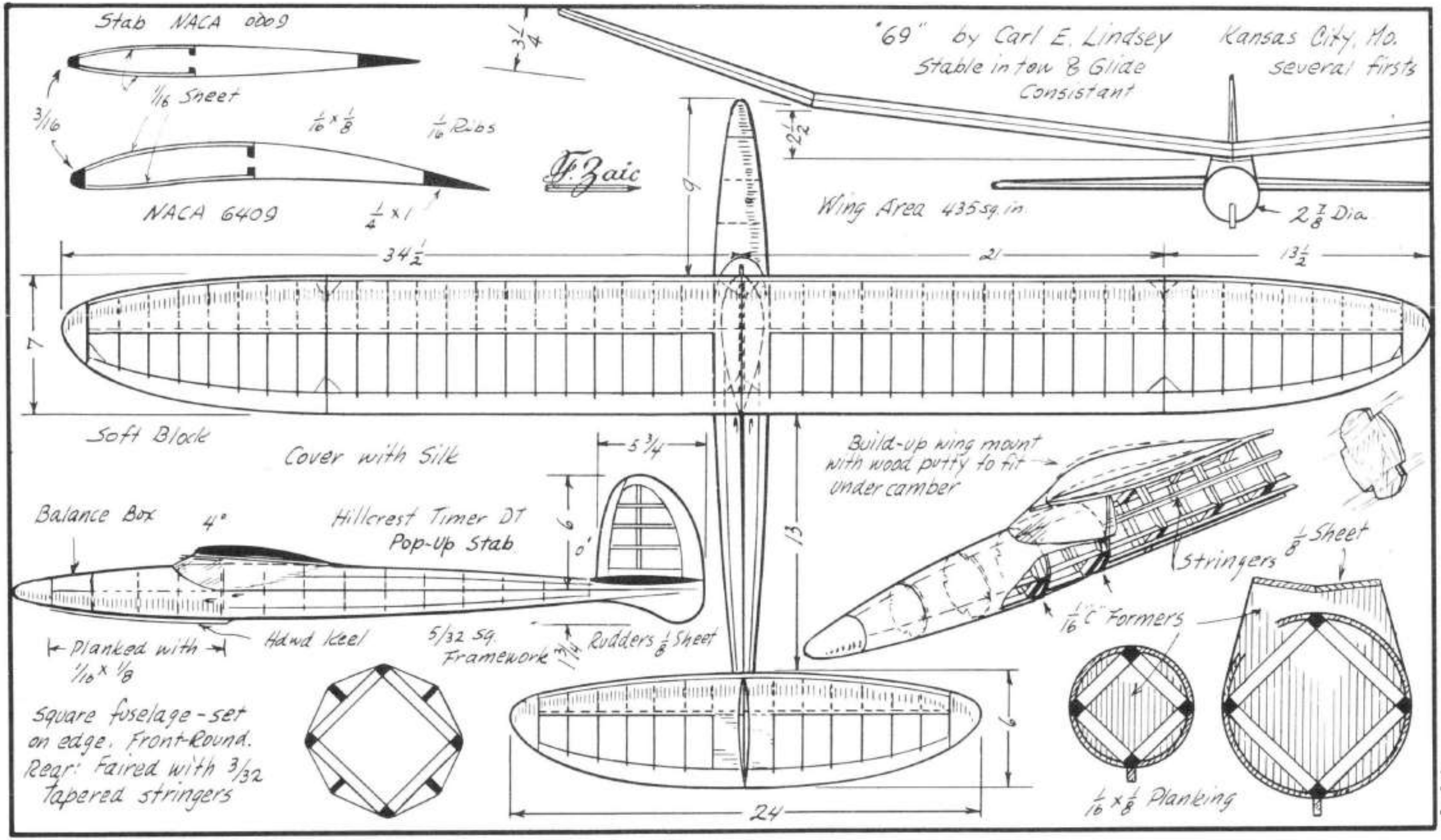
(*Continued on page 564*)


1/8 sq Balsa
3/32 x 7/16 Hd. Wd.
1/8 x 3/8 Balsa
Rubber & Hook Connections
4
1/20 Balsa
1/8 x 1/4 Balsa
1/8 x 5/8 Hd. Wd.
1/8 x 1/4 Hd. Wd.
1/16 Balsa
Gött. 413
9 1/2
82
Wt. 810 gm.
Flights limited to 300 secs.
1st à ROUEN — 300s + 291
1st à COMPIEGNA — 296 + 300 + 300
2nd à PÉRONNE 17 mts on 2 Flt
100 m. towline
1" sq. Boom
1/8 Balsa Sides
8
1/8 x 5/8 Hd. Wd.
8
9 1/2
36 1/2
3
2 3/4
2 3/4
Removable Boom
5
9
3/32 Balsa Rudder
See "MARINA" fo strut Costruction
1/20 Plywood
27
Fuselage covered with 1/16 Balsa
1/8 sq Longerons
1/8 Blkhds
CHAMPION de FRANCE 1950
J.L.23 "ALLUMETTE"
by JACQUES LOCK - FRANCE
Aero Club de l'Oise
Duration 300 sec + 300 sec + 126 sec
8
Very slow glide
3/16 Plywood Skid
W. Zaic

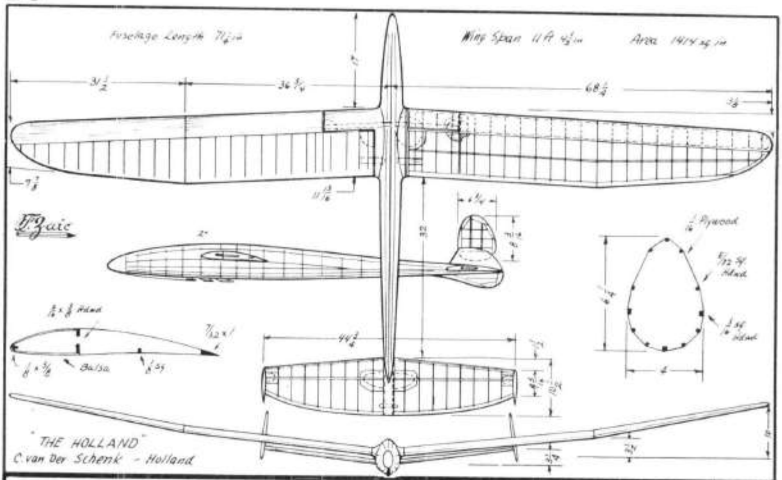

Full Size Plan 50¢
Kit $4.50
7/32 x 3/4
3/16 sq
3/16 x 1/2
3/16 sq
7/32 x 3/4
3/16 x 5/8
3/16 x 3/8
19
23
42
10
9
Empty Wt. 14 oz. (Tissue)
Wing Area 720 sq. in. Length 42"
4
2
14 1/2
30
6 1/2
3 1/2
Designed as a basic glider for R/C. Light construction to keep final wing loading light. It can be modified for specific conditions. Many cover fuselage with 1/16 Sheet.
Very stable in small circles which are necessary for Glider R/C to keep it from drifting too far. – About 50 kits released for field check. Seems OK. R/C on slopes tow, and light power.
10
Highest duration reported: 4 hours
9
1 1/2
.09 Engine
Stab & Rudder Tie – for R/C
6°
0°
R.C.
F.F.
3
2
RAYDIC G-84
Frank Zaic
3/16 sq. hard – Fuselage
F. Zaic
Power flown with full R/C Load
Can be towed or Hand Launched

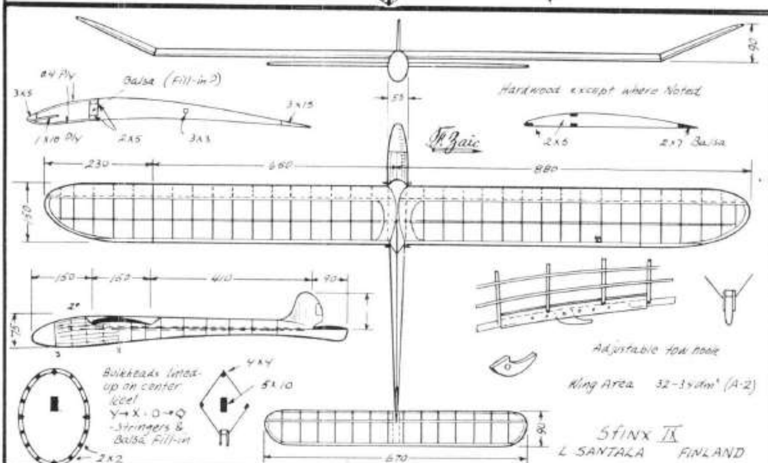


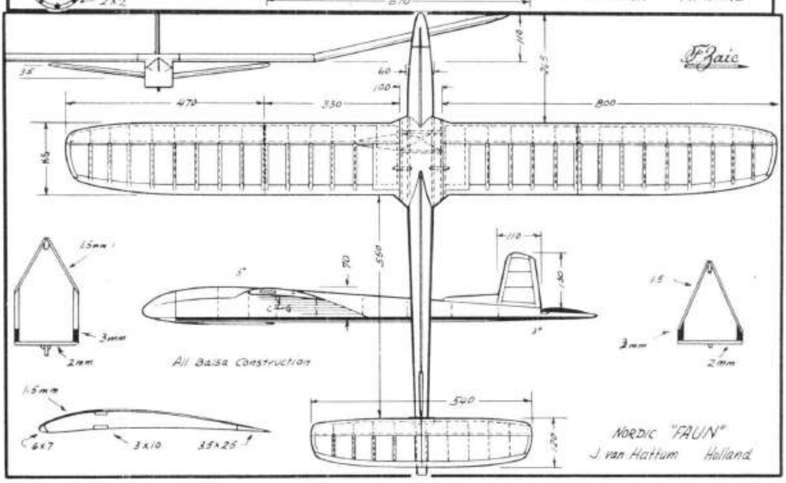
Wing 3.6oz. Stab .75oz
Fus & Pod 5.5oz Rudder .25oz
N.Z. Req. Wt. 14oz. Add Wt. at C.G.
Wing Area 440 sq. in
Clark YH
5/32 sq
1/8 x 5/16
1/8 x 1/4
5/32 x 1/2
36
24
12
6 1/2
2 1/2
"Golf Stick" for towing aid
9
6 1/2
16 1/4
6
7
1/16 x 1/8
1/8 x 1/4
Hinge
1/2 x 1 1/2 x 27 3/4
Hard Balsa
7/8
Box for Rudder which is removable
Hinge: Brass tubes fixed to Stab
1/20 sheet
1/8 sq.
1/20 x 1 1/4
5/32 sq
NACA 6409
5/64 x 1/2
F. Zaic
1947 N.Z. Nats 5m 54s. O/S
N.Z. 100 ft. tow Record 9m 45s O/S
N.Z. 300 ft. tow Record 11m 51s O/S
Very stable especially spirally
1/2" Hard center outline
POD: Med. Balsa 2 pcs.
6 x 1 Hollowed to about 3/16 Walls
5
28
NEW ZEALAND RECORD
Vern Grey Auckland, N.Z.

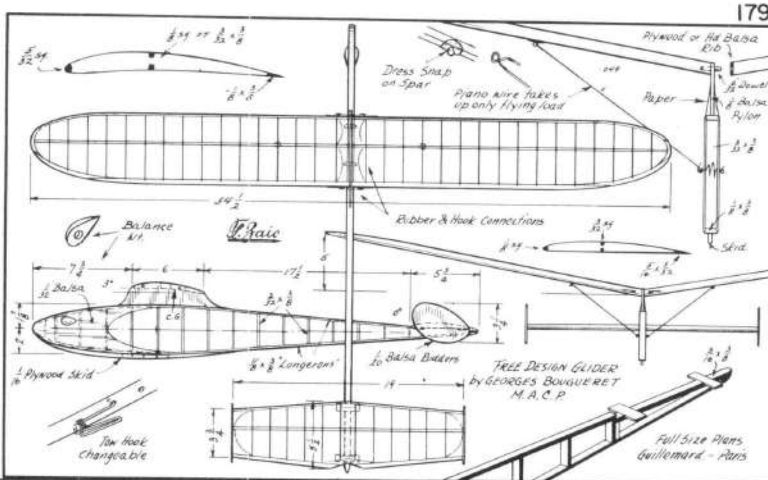


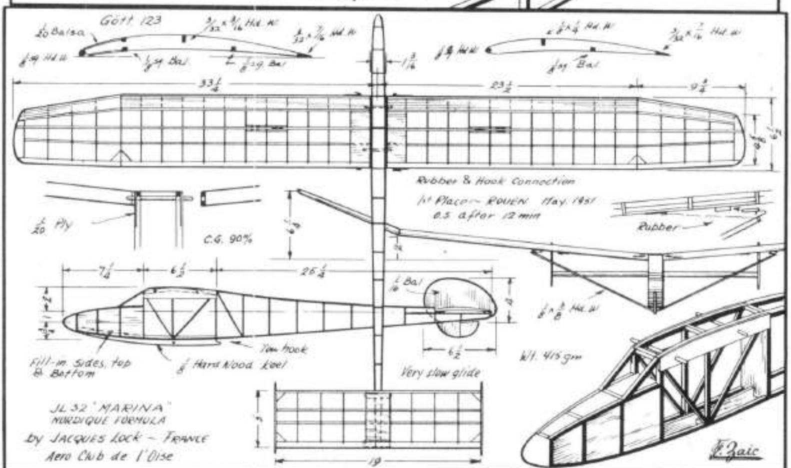
"69" by Carl E. Lindsey
Kansas City, Mo.
Stable in tow & Glide Consistant
several firsts
Stab NACA 0009
1/16 Sheet
3/16
1/16 x 1/8
1/16 Ribs
NACA 6409
1/4 x 1
F. Zaic
3 1/4
2 1/2
9
Wing Area 435 sq. in.
2 7/8 Dia.
34 1/2
21
13 1/2
7
Soft Block
Cover with Silk
5 3/4
Build-up wing mount with wood putty to fit under camber
Balance Box
4°
Hillcrest Timer DT
Pop-Up Stab
6
0°
13
Stringers
1/8 Sheet
1/16 "C" Formers
Planked with 1/16 x 1/8
Hard Keel
5/32 sq. Framework
1 3/4
Rudders 1/8 Sheet
Square fuselage - set on edge. Front-Round. Rear: Faired with 3/32 tapered stringers
6
24
1/16 x 1/8 Planking

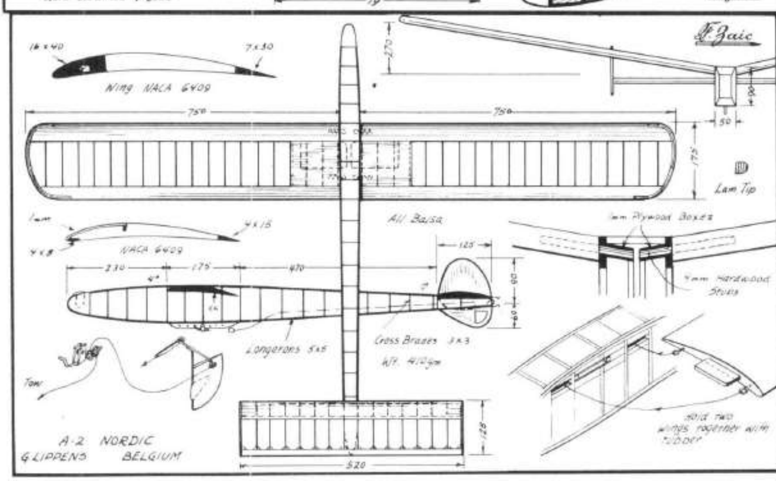

Fuselage Length 71½ in
Wing Span 11 ft 4½ in
Area 1414 sq in
F. Zaic
1/16 Plywood
Balsa
"THE HOLLAND"
C. van Der Schenk - Holland

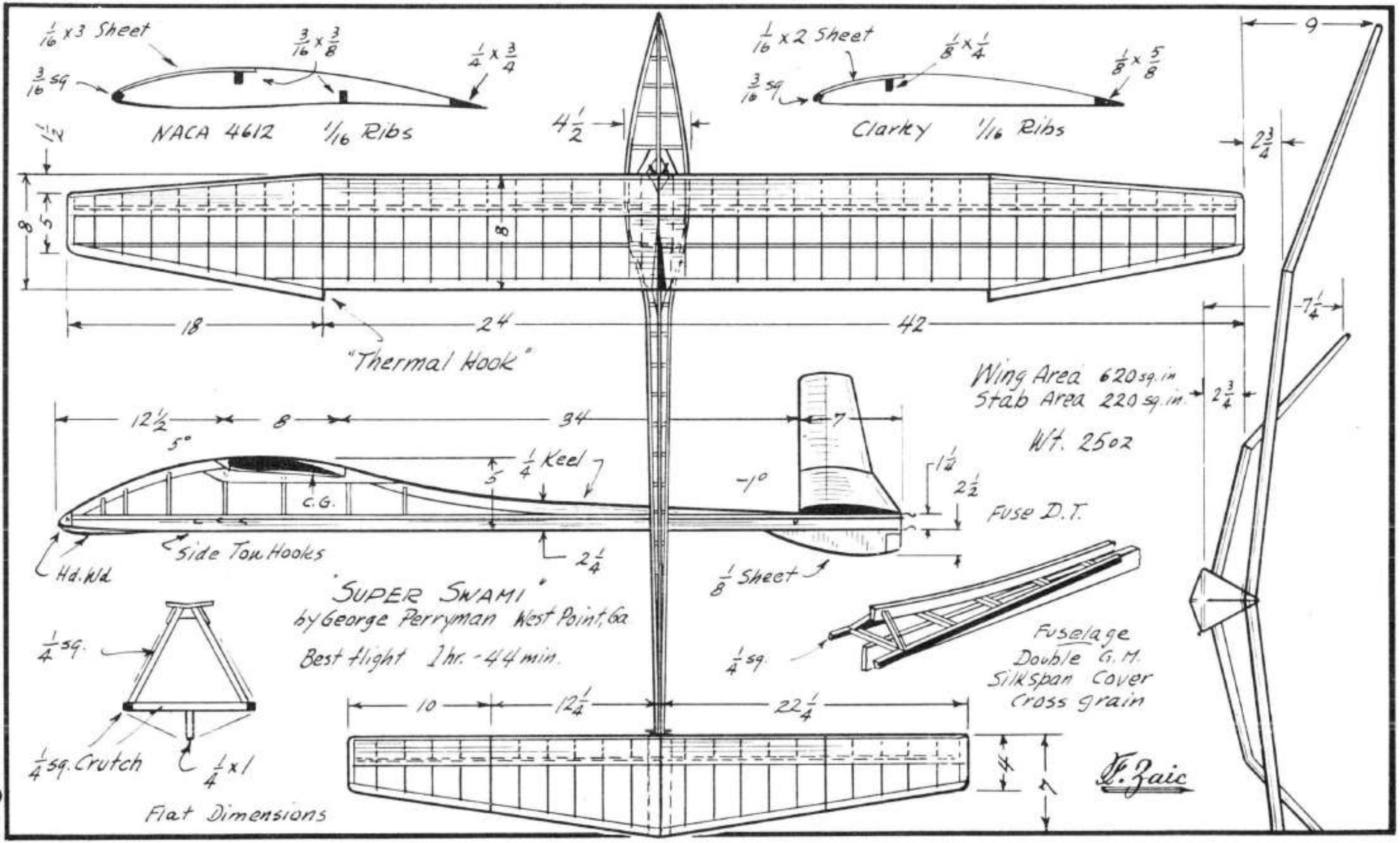

0.4 Ply
Balsa (Fill-in ?)
1x10 Ply
Hardwood except where Noted
F. Zaic
2x7 Balsa
Adjustable tow hook
Bulkheads lined-up on center keel
Y→X→O→Q
-Stringers & Balsa Fill-in
Wing Area 32-34 dm² (A-2)
Sfinx IX
L. SANTALA FINLAND

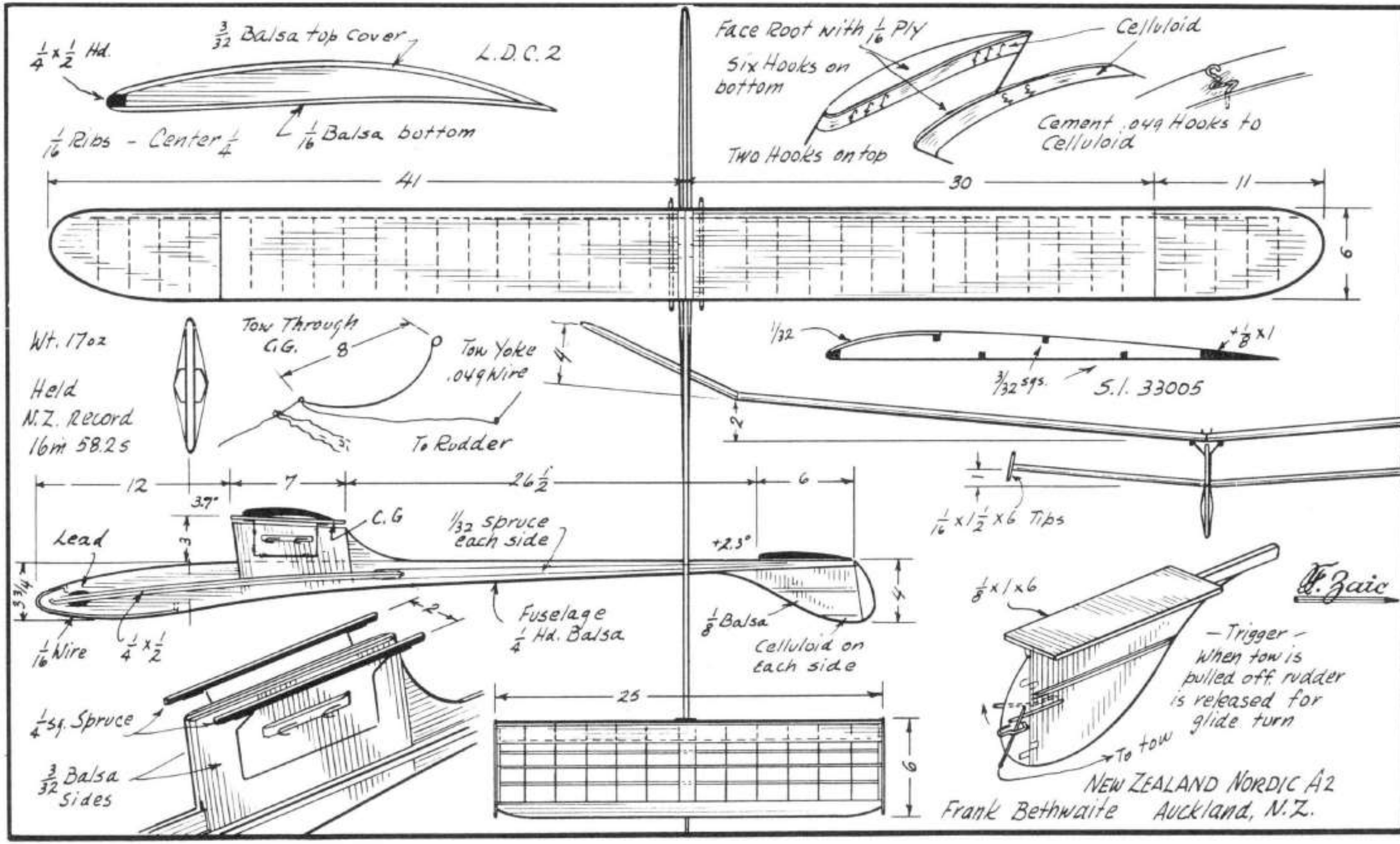

F. Zaic
All Balsa Construction
NORDIC "FAUN"
J. van Hattum Holland


Dress Snap on Spar
Piano wire takes up only flying load
Plywood or Hd Balsa Rib
Paper
Pylon
Skid
Balance Wt.
Rubber & Hook Connections
Balsa
C.G.
"Longerons"
Balsa Rudders
Plywood Skid
Tow Hook Changeable
TREE DESIGN GLIDER
by GEORGES BOUGUERET
M.A.C.P.
Full Size Plans
Guillemard - Paris

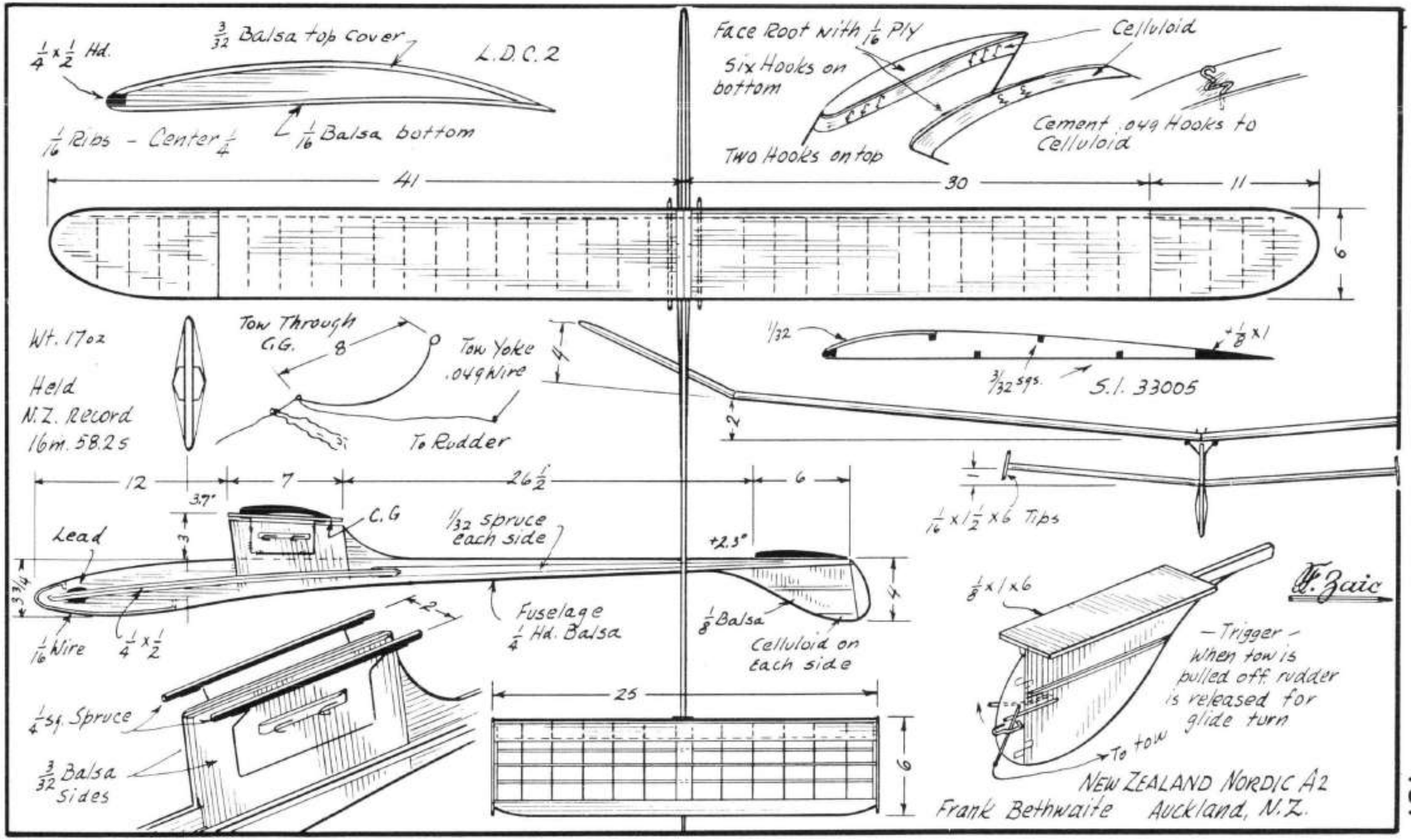

Gött. 123
Balsa
Rubber & Hook Connection
1st Place - ROUEN May 1951
0.5 after 12 min
Rubber
Ply
C.G. 90%
Bal
Tow hook
Hard Wood Keel
Fill-in Sides, top & Bottom
Very slow glide
Wt. 415 gm
JL 32 "MARINA"
NORDIQUE FORMULA
by JACQUES LOCK - FRANCE
Aero Club de l'Oise


16 x 40
7 x 30
Wing NACA 6409
750
750
175
Lam. Tip
All Balsa
1mm Plywood Boxes
4 x 15
4 x 8
NACA 6409
230
175
470
125
Longerons 5x5
Cross Braces 3x3
Wt. 410 gm
Tow
1mm Hardwood Stubs
Hold two wings together with rubber
A-2 NORDIC
G. LIPPENS BELGIUM
520

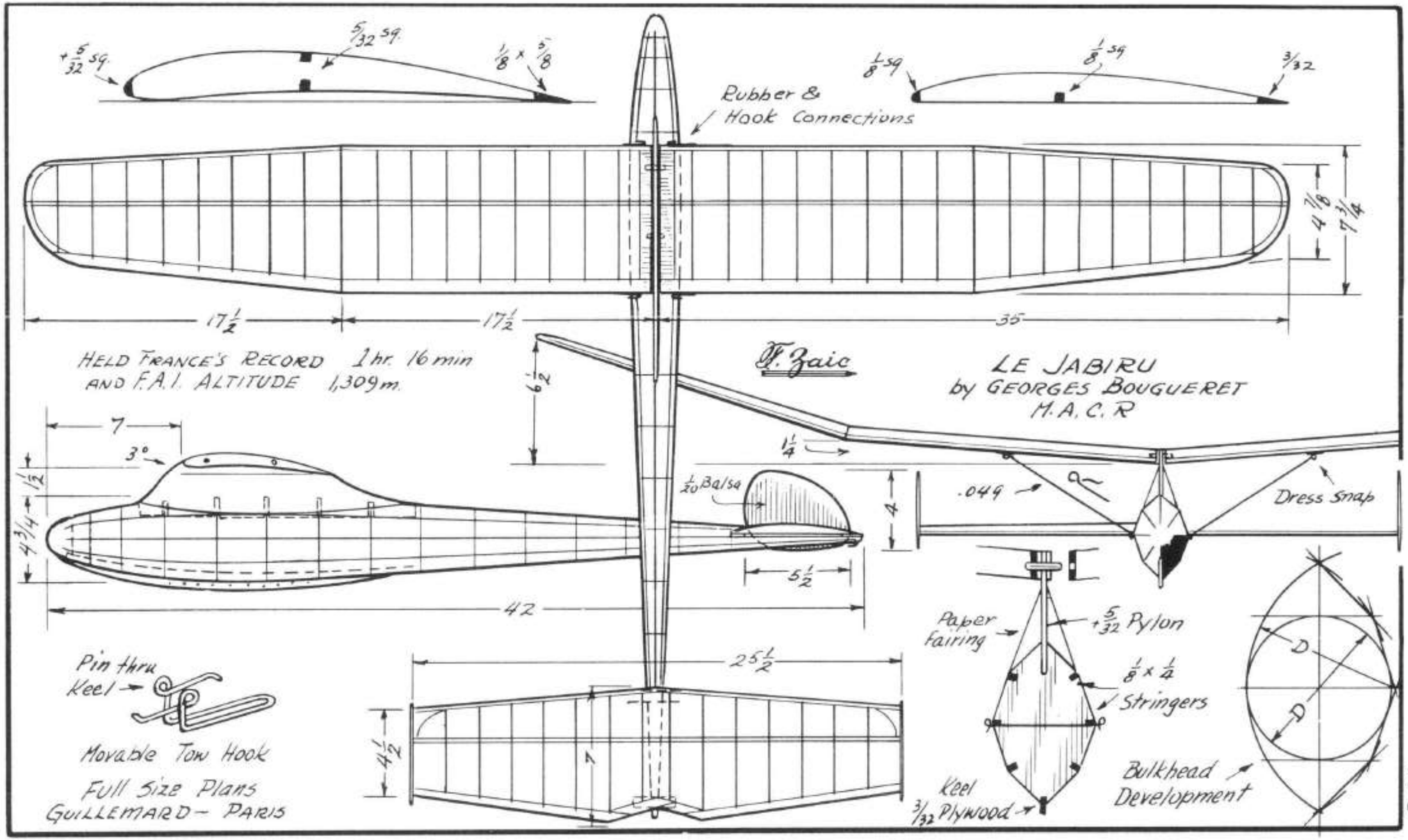

1/16 x 3 Sheet
3/16 x 3/8
1/4 x 3/4
3/16 sq
NACA 4612
1/16 Ribs
1/16 x 2 Sheet
1/8 x 1/4
1/8 x 5/8
3/16 sq
Clarky
1/16 Ribs
4 1/2
1/2
8
5
8
18
24
42
"Thermal Hook"
9
2 3/4
7 1/4
2 3/4
Wing Area 620 sq. in
Stab Area 220 sq. in.
Wt. 25 oz
12 1/2
8
34
7
5°
1/4 Keel
5
C.G.
-1°
1 1/4
2 1/2
Fuse D.T.
Side Tow Hooks
2 1/4
Hd. Wd
1/8 Sheet
"SUPER SWAMI"
by George Perryman West Point, Ga
Best flight 1 hr. - 44 min.
1/4 sq.
1/4 sq.
Fuselage
Double G.M.
Silkspan Cover
Cross grain
10
12 1/4
22 1/4
4
7
1/4 sq. Crutch
1/4 x 1
Flat Dimensions
F. Zaic



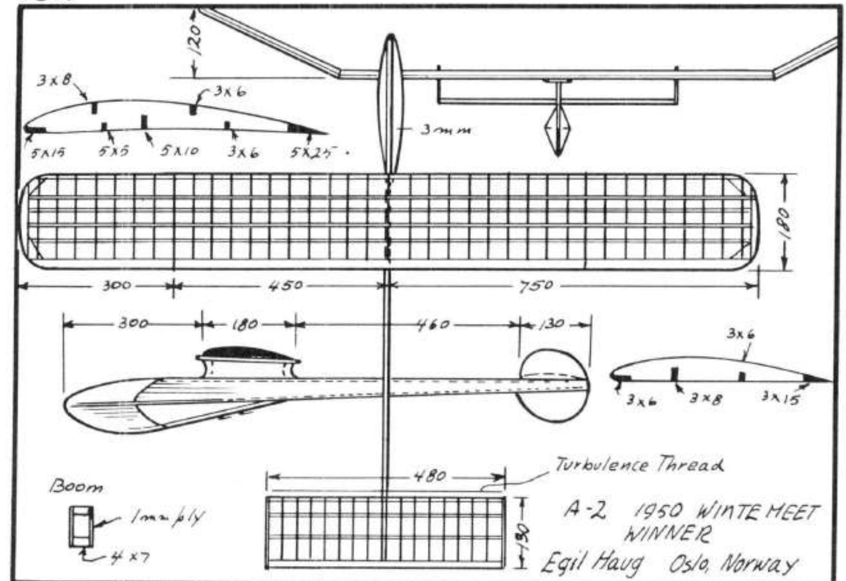
$\frac{3}{32}$ Balsa top cover
$\frac{1}{4}$ x $\frac{1}{2}$ Hd.
L.D.C. 2
$\frac{1}{16}$ Ribs - Center $\frac{1}{4}$
$\frac{1}{16}$ Balsa bottom
Face Root with $\frac{1}{16}$ Ply
Celluloid
Six Hooks on bottom
Two Hooks on top
Cement .049 Hooks to Celluloid
41
30
11
6
Wt. 17oz
Held N.Z. Record 16m 58.2s
Tow Through C.G.
8
Tow Yoke .049 Wire
To Rudder
4
2
1/32
+$\frac{1}{8}$ x 1
3/32 sqs.
S.I. 33005
12
7
26$\frac{1}{2}$
6
3.7°
C.G
1/32 spruce each side
+2.3°
3
Lead
3 3/4
$\frac{1}{16}$ Wire
$\frac{1}{4}$ x $\frac{1}{2}$
2
Fuselage $\frac{1}{4}$ Hd. Balsa
$\frac{1}{8}$ Balsa
Celluloid on each side
4
$\frac{1}{16}$ x 1$\frac{1}{2}$ x 6 Tips
$\frac{1}{8}$ x 1 x 6
F. Zaic
$\frac{1}{4}$ sq. Spruce
$\frac{3}{32}$ Balsa Sides
25
6
— Trigger — When tow is pulled off rudder is released for glide turn
To tow
NEW ZEALAND NORDIC A2
Frank Bethwaite Auckland, N.Z.

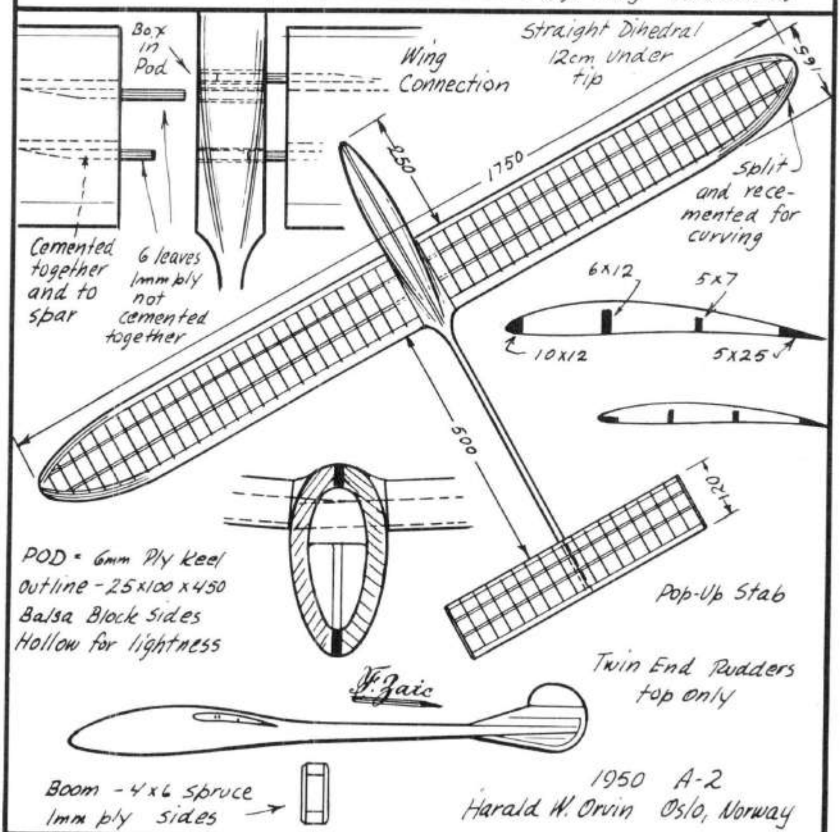


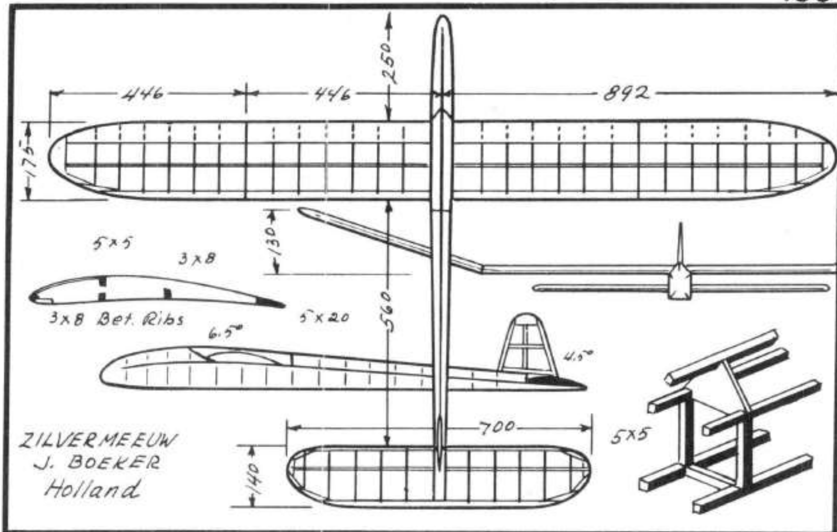
1/4 x 1/2 Hd.
3/32 Balsa top cover
L.D.C. 2
1/16 Ribs - Center 1/4
1/16 Balsa bottom
Face Root with 1/16 Ply
Six Hooks on bottom
Two Hooks on top
Celluloid
Cement .049 Hooks to Celluloid
41
30
11
6
Wt. 17 oz
Held N.Z. Record 16m. 58.2 s
Tow Through C.G.
8
Tow Yoke .049 Wire
To Rudder
4
2
1/32
+1/8 x 1
3/32 sqs.
S.I. 33005
1
1/16 x 1 1/2 x 6 Tips
12
7
26 1/2
6
3.7°
3
C.G
1/32 spruce each side
Lead
+2.3°
3 3/4
1/16 Wire
1/4 x 1/2
2
Fuselage 1/4 Hd. Balsa
1/8 Balsa
Celluloid on each side
4
1/4 sq. Spruce
3/32 Balsa Sides
25
6
1/8 x 1 x 6
F. Zaic
-Trigger- When tow is pulled off rudder is released for glide turn
To tow
NEW ZEALAND NORDIC A2
Frank Bethwaite Auckland, N.Z.



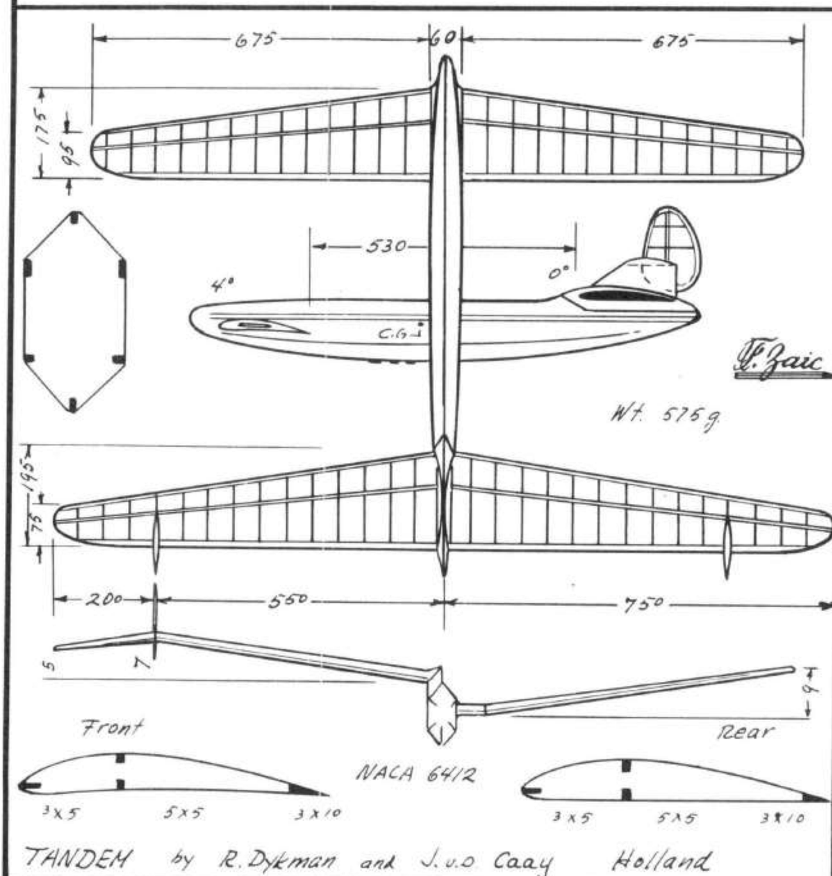
LE JABIRU
by GEORGES BOUGUERET
M.A.C.R
HELD FRANCE'S RECORD 1 hr. 16 min
AND F.A.I. ALTITUDE 1,309 m.
F. Zaic
Rubber & Hook Connections
5/32 sq.
1/8 x 5/8
1/8 sq
3/32
17 1/2
35
4 7/8
7 3/4
6 1/2
1 1/4
7
3°
1 1/2
4 3/4
1/20 Balsa
5 1/2
42
4
.049
Dress Snap
Paper Fairing
5/32 Pylon
1/8 x 1/4 Stringers
Keel 3/32 Plywood
Bulkhead Development
D
25 1/2
4 1/2
Pin thru Keel
Movable Tow Hook
Full Size Plans
GUILLEMARD - PARIS


120
3x8
3x6
5x15
5x5
5x10
3x6
5x25
3mm
300
450
750
180
300
180
460
130
3x6
3x6
3x8
3x15
Turbulence Thread
480
130
Boom
1mm ply
4x7
A-2 1950 WINTE MEET WINNER
Egil Haug Oslo, Norway

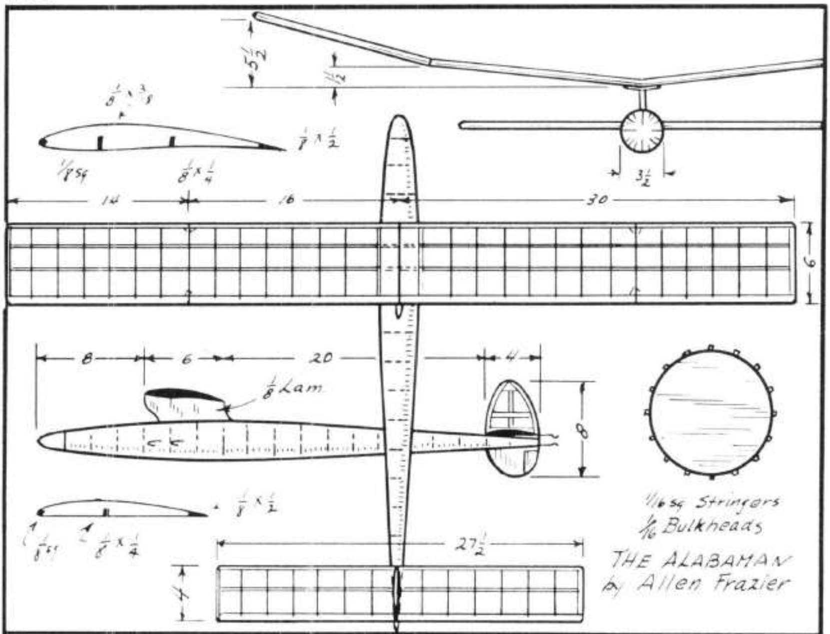

Box in Pod
Wing Connection
Straight Dihedral 12cm Under tip
165
250
1750
Split and recemented for curving
Cemented together and to spar
6 leaves 1mm ply not cemented together
6x12
5x7
10x12
5x25
500
120
POD = 6mm Ply Keel outline - 25x100 x 450 Balsa Block Sides Hollow for lightness
Pop-Up Stab
Twin End Rudders top only
F. Zaic
Boom - 4x6 spruce 1mm ply sides
1950 A-2
Harald W. Orvin Oslo, Norway

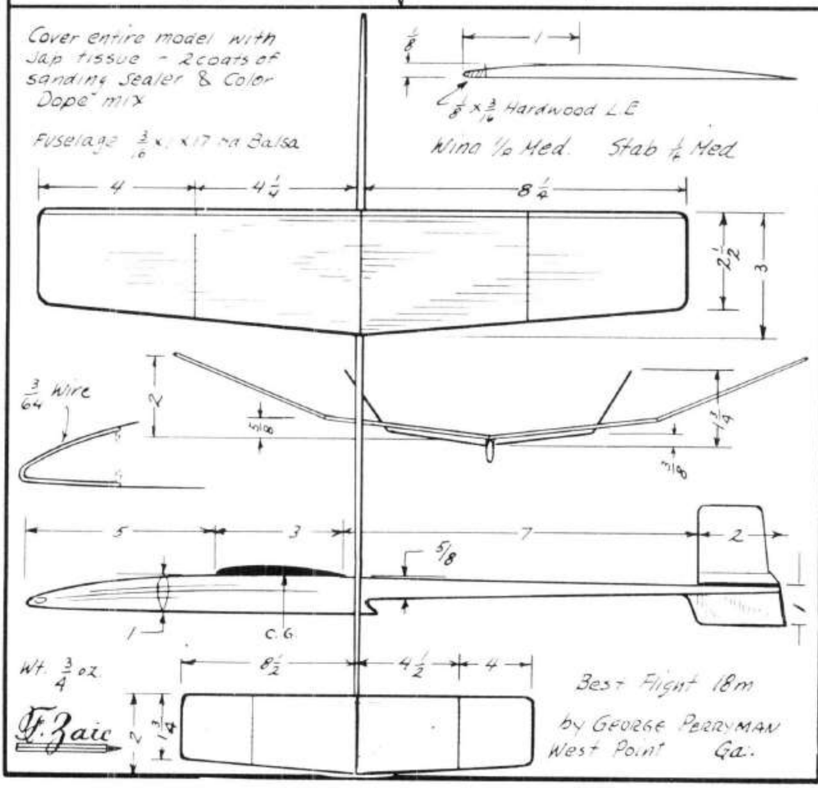


446
446
250
892
175
130
560
5x5
3x8
3x8 Bet. Ribs
5x20
6.5°
4.5°
700
5x5
140
ZILVERMEEUW
J. BOEKER
Holland

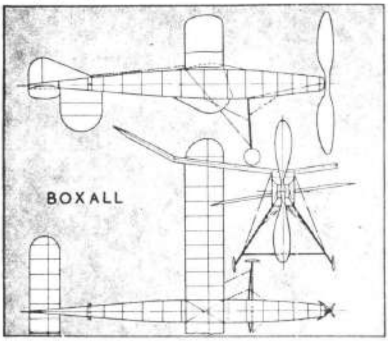


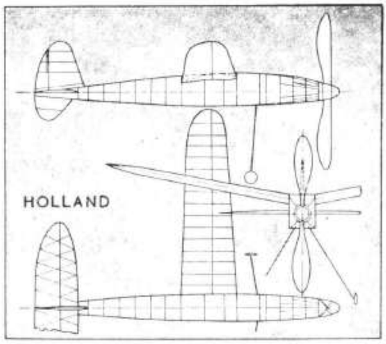
675
60
675
175
95
530
4°
0°
C.G.
F. Zaic
Wt. 575 g.
195
75
200
550
750
5
7
9
Front
Rear
NACA 6412
3x5
5x5
3x10
3x5
5x5
3x10
TANDEM by R. Dykman and J. v.d. Caay Holland

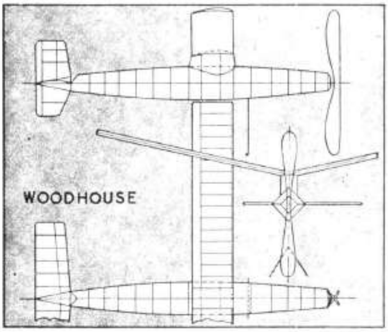

1/8 x 3/8
1/8 x 1/2
1/8 sq
1/8 x 1/4
1/8 Lam.
1/16 sq Stringers
1/16 Bulkheads
THE ALABAMAN
by Allen Frazier

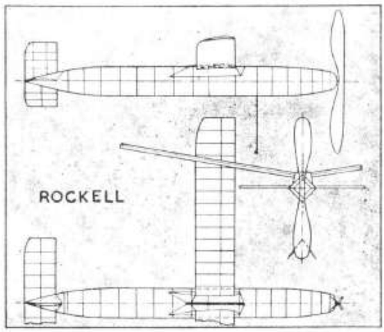

Cover entire model with Jap tissue - 2 coats of sanding Sealer & Color Dope mix
1/8 x 3/16 Hardwood L.E
Wing 1/16 Med. Stab 1/16 Med
3/64 Wire
C.G.
Wt. 3/4 oz.
F. Zaic
Best Flight 18m
by George Perryman
West Point Ga.

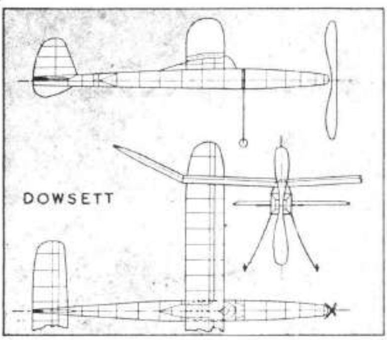
BRITISH TEAM FOR 1951 WAKEFIELD

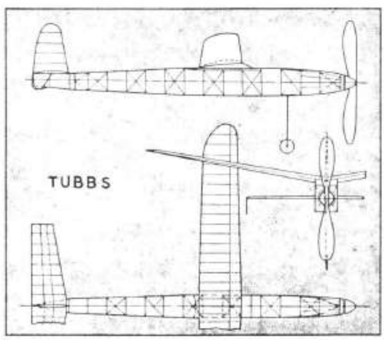












ENTRANT	WING			TAILPLANE			FIN		FUSELAGE		Wing Position	Under-carriage	MOTOR				PROPELLER			Total Weight	Remarks
	Span	Chord	Section	Span	Chord	Section	Height	Chord	Length	Cross-Section			Strands	Length	Section	Make		Pitch	Type		
	ins.	ins.		ins.	ins.		ins.	ins.	ins.	ins.				ins.	ins.		ins.	ins.			
F. H. Boxall (Brigsons)	43½	5	N.A.C.A. 6412	20	7	Gott. 602	6	5½	38	3 × 3½ Rectangular	High	Bamboo (Thread Braced) Twin wheel	14	50	¼ × 1/24	Dunlop	18	26	Fixed blade freewheeler	8½ oz.	Tip-up wing D/T. Underslung main fin. Trim tabs above tail. Central "neutral" fin.
F. Holland (Swansea)	43½	5.4	Joukowski	19	5	Thinned Clark Y	6½	4	36	[illegible] × 2½ Rectangular	Shoulder	Bamboo plug-in wheel	14	48	¼ × 1/24	Dunlop	18	27½	Fixed blade freewheeler	8½ oz.	Geodetic tail. $\frac{1}{16} \times \frac{1}{16}$ longerons set radially from C/L Fuselage.
K. Woodhouse (Whitefield)	45	5	M.V.A. 301	23	4	60% Clark Y	6 / 4½	4	38½	2½ × 2½ Diamond	Pylon	16 and 18 s.w.g. single leg (twin skid)	17	44	¼ × 1/24	Dunlop	18	38	Fixed blade freewheeler	8·4 oz.	Fin area 50/50 above/below C/L fuselage. wing section prop.
W. Rockell (Gainsborough)	46	5	Davis	16	4	89% Clark Y	4 / 3½	4	42	10.2 sq. ins. Diamond	High	Wire single leg (twin skid)	14	55	¼ × 1/24	Dunlop	18	31	Fixed blade freewheeler	8⅝ oz.	Fins have reversed lifting sections.
I. Dowsett (Pharos)	44½	5	N.A.C.A. 6409	18	4½	Flat Plate	5½	6	41½	10.5 sq. ins. Sq. plus pylon	Pylon	Plug-in wire Twin wheel	14	52	¼ × 1/24	Dunlop	18	36	Fixed blade freewheeler	8.15 oz.	Tip up tail D/T.
H. Tubbs (Leeds)	46	4½	Davis	21½	3½	60% Clark Y	6	4.6	42	2½ × 3½ Rectangular	High	16 s.w.g. wire mono-wheel	16	50	¼ × 1/24	Pirelli	18	32	Fixed blade freewheeler	9.5 oz.	Tip-up tail D/T. Twin underfins.

ORNITHOPTERS

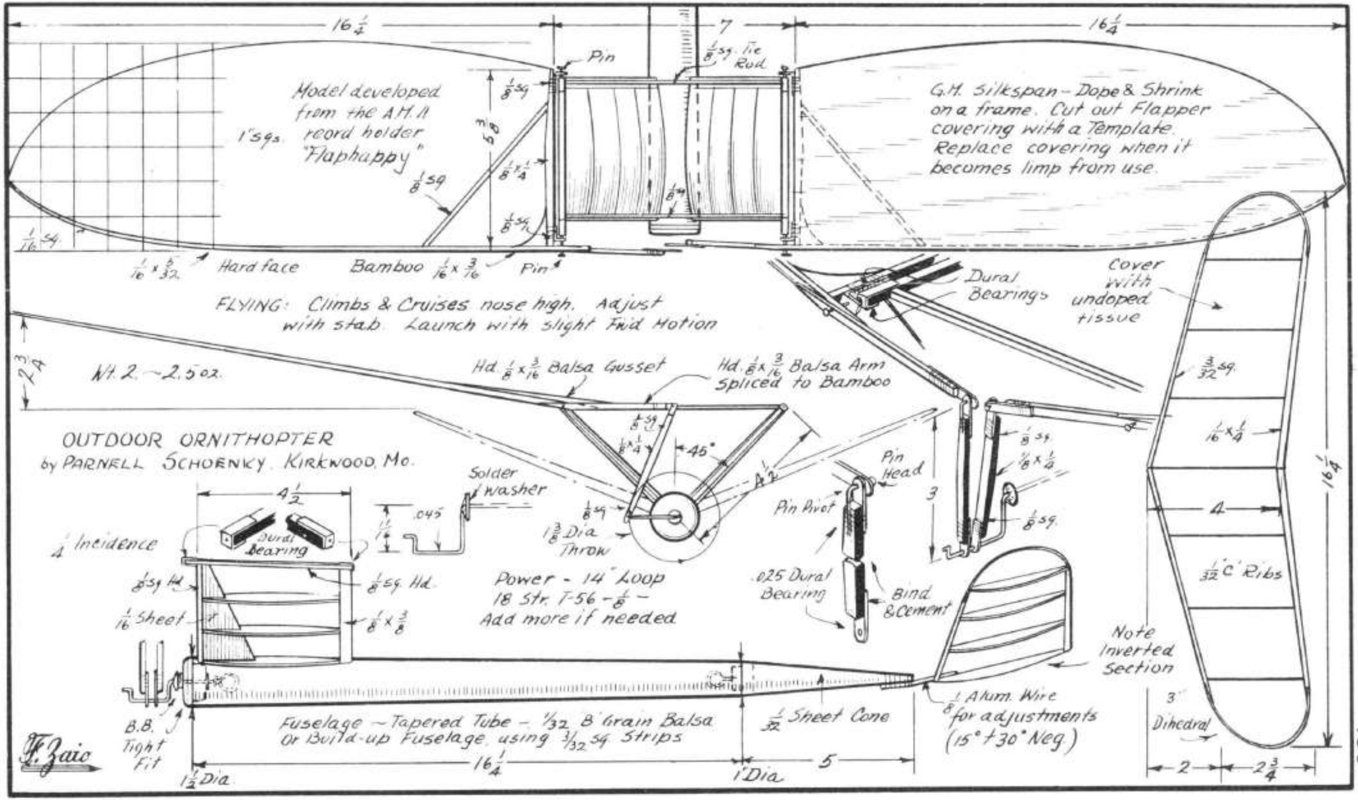
by Parnell Schoenky

The points to consider first in any ornithopter design are a high power-to-weight ratio and strength and reliability of working parts. This latter requirement includes not only the flapper lever arms and the conrods, but also the flapper supports and the motor tube just behind the noseplug. Putting a lot of music wire, hardwood, and hard sheet balsa into an "outdoor" ornithopter will not produce sufficient ruggedness to take the large amount of rubber needed for long flights; instead, the strength must be built in by careful design and by very careful selection of balsa. And when building an ornithopter it's well to forget old ideas about saving weight by using glue sparingly. The wood should break before the cemented joints come loose; anything less means your model is lugging around "dead" wood. Remember, no model takes a beating more severe than does the business end of a flapper.

In the hundreds of years that men have been experimenting with flapping-wing flight, countless complicated and fancy arrangements of flappers and actuating mechanisms have been tried. We are still far from the true bird wing with its complex system of slots, flaps, and camber variance, and the best-flying ornithopters are really not ornithopters at all, but entomopters—"bug-wing" models. The usual result of attempts to add feathers and complex motion to model flappers is that the added weight and friction absorb power without adding to efficiency. The best way to improve the flight of a flapper is to systematically test and retest such basic items as the flapper covering etc. until one is sure that each part is doing its utmost. Taking the covering as a good axample, try flying a flapper until the paper is limp and loose, and then replace it with fresh taut covering. In most cases the duration will immediately improve. The same approach should be used in trimming. Often a flapper which appears to be underpowered is only lacking negative incidence in the stabilizer, and again, a flapper which stalls after every launch may be suffering not from too much stabilizer negative but from "gas model launchitus." (Flappers need very little forward speed when launched, and on a breezy day it may even be necessary to release the model while walking downwind.)

Most people nowadays regard ornithopters (and entomopters) as just amusing toys. It wasn't too long ago that helicopters were in the same category, and look at them now. Some of our farseeing scientists are hard at work on flapping wing flight, believing that here is the key to such flight problems as slow and hovering flight, maneuverability, and ultra-safe landings. Given its share of research, the flapping wing aircraft may yet surprise us all.

The modelers who would like additional information on ornithopters are referred to the following articles published in the British model periodical, The AEROMODELLER: 1) An excellent background article on ornithopters, by Laidlaw-Dickson, in


16 1/4
7
16 1/4
Pin
1/8 sq. Tie Rod
Model developed from the A.M. A. record holder "Flaphappy"
1" sqs.
5 3/8
1/8 sq
1/8 x 1/4
1/8 sq
1/8 sq
1/8 sq
1/16 sq.
1/16 x 5/32
Hard face
Bamboo 1/16 x 3/16
Pin
G.M. Silkspan - Dope & Shrink on a frame. Cut out Flapper covering with a Template. Replace covering when it becomes limp from use.
Dural Bearings
Cover with undoped tissue
FLYING: Climbs & Cruises nose high. Adjust with stab. Launch with slight Fwd. Motion
2 3/4
Wt. 2. ~ 2.5 oz.
Hd. 1/8 x 3/16 Balsa Gusset
Hd. 1/8 x 3/16 Balsa Arm Spliced to Bamboo
3/32 sq.
OUTDOOR ORNITHOPTER
by PARNELL SCHOENKY, KIRKWOOD, Mo.
1/8 sq
1/8 x 1/4
45°
4 1/2
1/8 sq
1 3/8 Dia Throw
Pin Head
Pin Pivot
3
1/8 sq.
1/8 x 1/4
1/8 sq.
1/16 x 1/4
16 1/4
4
4 1/2
Solder Washer
.045
1 1/16
1/4 Incidence
Dural Bearing
1/8 sq. Hd.
1/8 sq. Hd.
1/16 Sheet
1/8 x 3/8
Power - 14" Loop
18 Str. T-56 - 1/8 -
Add more if needed
.025 Dural Bearing
Bind & Cement
1/32 "C" Ribs
Note Inverted Section
3° Dihedral
B.B. Tight Fit
Fuselage ~ Tapered Tube - 1/32 "B" Grain Balsa
Or Build-up Fuselage, using 3/32 sq. Strips
1/32 Sheet Cone
1/8 Alum. Wire for adjustments (15° + 30° Neg.)
16 1/4
5
1 1/2 Dia
1" Dia
2
2 3/4
F. Zaic

NOTES ON THE AUTOGYRO

by Parnell Schoenky

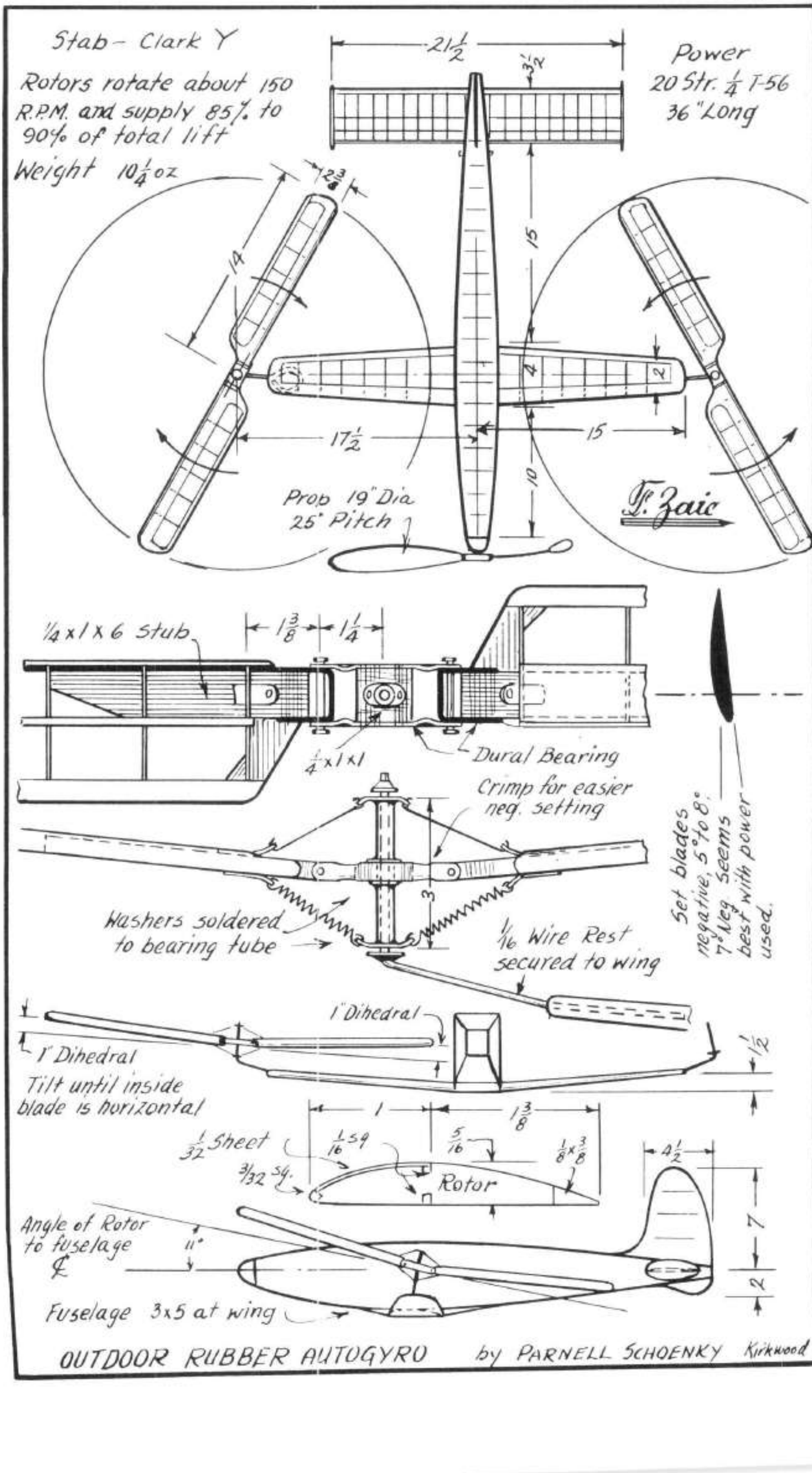
The model autogiro field is probably the least developed of all unconventional types of models. In a sense this is good, for there is so much virgin territory in which the experimenter may ramble freely, without duplicating the work of others. Another aspect of the 'giro is its close similarity to the full-scale craft; the model 'giro looks and flies much like a Kellett or a Pitcairn, whereas it's a rare helicopter model that can be identified as such—except by its owner.

The 'giro shown on the plans was not an off-the-board flight success; in fact, it presented more trimming problems than any other type which I have attempted. This most probably resulted from a miscalculation of the required rotor area relative to the size of the rest of the craft. The first design utilized twin rotors, mounted parasol style on a small fixed wing, and exhibited disastrous stall characteristics. The model would go into a progressive stall after 50 yards or so of slow level flight, and as the rotors continued to churn away steadily (result of the increased angle of attack) the model would lose forward speed to the point where the stab would suddenly stall out completely and the model would execute a backflip. Changes of incidence, rotor angles, C.G., and downthrust were of no avail in controlling the eventual stall and served only to shorten the period of level flight. At this point I consider the use of a rotating stabilizer in place of the conventional fixed type—surely this one couldn't stall ahead of the wing. However, the obviously high center-of-resistance of the 'giro suggested a better solution: lowering of the rotors. A new cantilever mount with greater span was made, and is in use now on the configuration shown in the plans. The present arrangement has proven to be on the right track, leaving the way open for improvements to the tail surfaces and power plant. In the few stalls encountered with the shoulder-level rotors, a good conventional recovery was made in all but one case. The model lands slowly and gently, even when maladjusted, due to the high rotor lift at all flight attitudes. Rotor drag is considerable, as evidenced by the slow airspeed with Wakefield power.

The two-bladed twin rotors, which have a total blade area of approximately 100 square inches, actually generate lift equal to a wing of over 300 square inches. Efficiency, of course, is poor compared to an ordinary model wing, but the same set of rotors when fitted to a longer fuselage with larger stabilizer and a longer motor run will make possible flights of better than a minute.

— AUTOGYRO —

the October 1946 issue, and 2) a comprehensive discussion of ornithopter construction and trimming, in the October 1949 issue. Part of this latter article is supplied separately, as part of plan No. D-333, available from the Aeromodeller Plans Service.



OUTDOOR RUBBER AUTOGYRO by PARNELL SCHOENKY Kirkwood

AIRFOIL THEORY

Gail Cheesman

An airfoil theory which the author is currentiy preparing for early publication has dictated the design of an entire new family of airfoil sections especially for use on duration model airplanes. Based in attaining minimum sinking speed in the glide, the analysis suggests that important gains in duration can be achieved by combining high-aspect-ratio wings with deeply cambered airfoils, and, as in the past, adjusting models equipped with such airfoils to glide at near-stalling lift coefficients. It is believed that models with high-aspect-ratio wings in the past have often been hampered by insufficienly cambered airfoils, and that models with high-lift wings have generally suffered from inadequately low aspect ratios. The two effects, high aspect ratio and high-lift airfoils, apparently go hand in hand to increase duration.

In this brief article, no attempt will be made to describe the designation of the various series of airfoils in the family. However, ordinates of four of the sections are presented here. The 25-1.00-10 section, incidentally, was used on Joe Boyle's 1949 Wakefield models, both in the Augusta, Georgia eliminations and in the English finals. These models were smooth-flying, steady-climbing models on 14 strands of 1/4 T-56 rubber, and exhibited an unusually slow glide. The 25-1.00-10 section is recommended for general-purpose duration models and seems to combine sufficient structural strength with excellent performance at an aspect ratio of about 10:1.

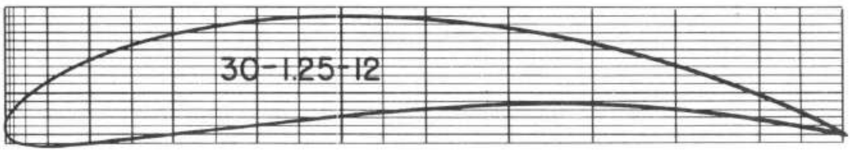
The author, however, predicts even higher performance with higher aspect ratios and deeper camber. Accordingly, two other wing sections are presented, the 30-1.25-12, and the 35-1.50-14. It is probable that the 30-1.25-12 airfoil will be particularly well suited to models of about 12:1 aspect ratio, and that the 35-1.50-14 will be particularly useful on models of 14:1 or greater aspect ratio.

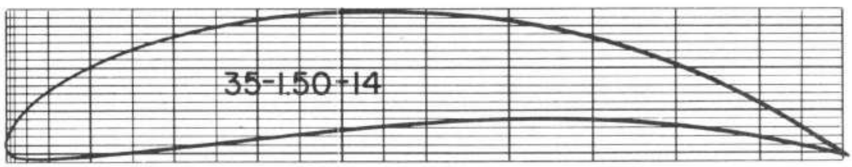
In addition to the use of high aspect ratios with these new airfoils, it is suggested that the forward part of the upper surface be sheeted with light sheet balsa to maintain the curvature. To minimize sag on wings using the 35-1.50-14 section, the entire upper surface might well be covered with thin sheet balsa covered on the inner side with Japanese tissue before sheeting and on outer side after sheeting. (1/64" sheet balsa so treated is excellent for rubber-powered models.)

In addition to three sections already mentioned, a special stabilizer section, the 20A-08, is also presented. The 20A-08 section is expected to stall at a rather high angle of attack for its thickness and should therefore improve the longitudinal stability of models flying on the verge of a stall. Since the current rules have made large stabilizer areas the rule rather than the exception, the induced drag of stabilizers at usual stabilizer aspect ratios has become a penalty to good performance. The suggested solution to this problem is to use fairly high aspect ratios on such large stabilizers. Stabilizer aspect ratios between 7:1 and 10:1 should prove adequate. Use of a stabilizer having an aspect ratio equal to or greater than that of the wing, however, is poor design, both structurally and aerodynamically.

A table of ordinates for the four mentioned airfoils follows, all ordinates expressed in percentage of the chord. It should be noticed that the leading edge of each of these sections extends slightly forward of the forward end of the chord line. Careful plotting and fairing of the nose section is required to obtain the proper leading-edge shape.

Mr. Cheesman is an Aeronautical Research Scientist with the National Advisory Committee for Aeronautics.





STATION	25-1.00-10		30-1.25-12		35-1.50-14		20A-08	
	UPPER ORDINATE	LOWER ORDINATE	UPPER ORDINATE	LOWER ORDINATE	UPPER ORDINATE	LOWER ORDINATE	UPPER ORDINATE	LOWER ORDINATE
0	1.60	0	1.80	0	1.90	0	4.00	2.00
0.5	2.35	-0.70	2.60	-0.5	2.85	-0.40	4.48	1.40
1.0	2.90	-1.00	3.30	-0.75	3.65	-0.60	4.92	1.16
2.5	4.10	-1.35	4.65	-1.10	5.20	-0.75	5.80	0.68
5.0	5.55	-1.55	6.35	-1.25	7.10	-0.75	6.60	0.28
7.5	6.70	-1.50	7.75	-1.15	8.65	-0.70	7.16	0.14
10.0	7.55	-1.35	8.85	-0.95	9.95	-0.50	7.48	0.06
15.0	8.85	-0.80	10.55	-0.45	12.10	0	7.88	0.02
20.0	9.75	-0.20	11.70	0.05	13.70	0.60	8.00	0
25.0	10.40	0.30	12.65	0.55	14.80	1.15	7.92	0
30.0	10.75	0.80	13.25	1.10	15.70	1.65	7.72	0
35.0	10.95	1.30	13.65	1.55	16.20	2.10	7.44	0
40.0	11.00	1.75	13.80	2.15	16.55	2.60	7.12	0
45.0	10.95	2.20	13.80	2.60	16.65	3.00	6.68	0
50.0	10.85	2.55	13.60	3.00	16.50	3.35	6.20	0
60.0	10.05	3.05	12.75	3.55	15.55	4.00	5.20	0
70.0	8.70	3.20	11.05	3.70	13.75	4.20	4.00	0
80.0	6.55	2.80	8.45	3.15	10.55	3.40	2.76	0
90.0	3.50	1.50	4.55	1.70	5.80	1.85	1.40	0
95.0	1.75	0.75	2.35	0.85	2.95	0.90	0.72	0
100.0	0	0	0	0	0	0	0	0

DRAG OF CONTROL LINES AND MODELS

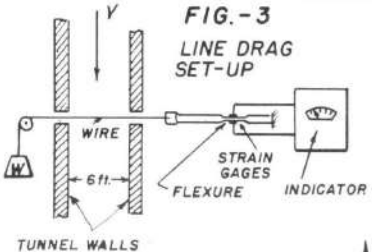
During the summer of 1950, several members of the Tech Model Aircrafters at M.I.T. near Boston, Mass., started on a project to get reliable data on the drag of control-lines and speed models. So far, about 200 man-hours of testing and computing have resulted in the following report.

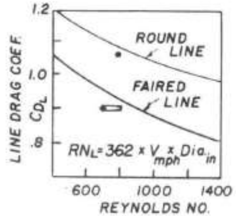
Through the help of Assistant Prof. E. E. Larrabee of the Aero Department (an active modeler in T.M.A.), the experiments were run in the modern 4.5′x 6.0′–100 m.p.h. Student Wind Tunnel which has very laminar (smooth-air) flow. To keep the Reynolds Number to that encountered on fast speed jogs at 150 mph, the mahogany replica was accurately made to 1.5 model size (see fig. 1). After proper corrections for support interference and drag and tunnel wall effects had been applied, final results have been found for lift, drag, and pitching moment (coefficients) over a wide range of angles of attack for three configurations: basic model without cylinder, model with exposed cylinder, and model with a simple helmet cowl. (See fig. 2). The important point is that addition of the exposed cylinder doubles the basic drag, but a good cowling only increases it by one third more; that is, *a cowled engine has one third the drag of an exposed engine.* This work was done by Henry Jex, Howie Wing, Gene Larrabee, Johnny Gionfriddo, Jack Stewart, and Myron Hoffman.

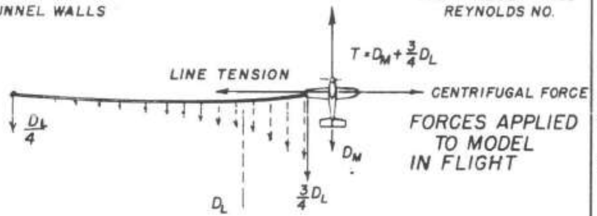
However, it was known that the majority of engine thrust went into line drag, so measuring equipment sensitive to ± 0.04 oz. was devised by Dick Baxter of Ruge de Forest, Consulting Engineers, making use of a cantilever beam and strain-gages. (See fig. 3). Runs were made at different speeds from 50 to 110 mph to determine the change of drag coefficients with Reynolds Number due to separation differences. (See fig. 4). Note that the line drag coefficient is based in the frontal area of the line (length x diameter).

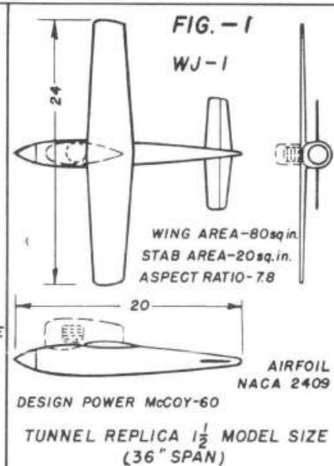
The addition of a light, rectangular 1/64″ x 3/64″ balsa fairing behind the lines reduced their drag by about 11%; but streamlining this fairing resulted in line vibration, probably due to separation phenomena. To prevent flutter, it is important that the C.G. of the line-plus-fairing be in front of the quarter-chord of the combination. There tests were performed by Dick Baxter, Bill O'Neill, Gene Larrabee, and Johnny Gionfriddo.

Now the values can be combined to check with control-line speed records. The overwhelming amount of power necessary to haul the lines around shows up well in fig. 5. The formula allows for drag variation along lines and the portion of drag taken out at the handle. It is apparent that more than *5/6 of the power goes into line drag near 150 mph.*, which means that drastic changes of model drag won't affect the speed appreciably. Evidently, even allowing for air density changes with temperature, the *big engines must be putting out over 1½ bhp* with 80% prop efficiency in order to achieve 160 mph. *Addition of line fairings* would probably *increase the top speed by 10 to 15 mph.* Also, use of a single .024 line would up the speed 10 to 15 mph, and if this could be successful streamlined, the speed might go up to 180 mph.









$$V_{mph} = \sqrt[3]{\frac{8350 \times bhp \times \eta_p}{\rho\left[\left(C_{D_M} \times \frac{S_M}{6}\right) + \left(d \times L \times C_{D_L}\right)\right]}}$$

ρ = Air Density--.00238 at Sea Level (60°F)

bhp = Brake Horsepower of Engine (Allowing for weather effects)

d = Diameter of Control Lines---Inches

L = Length of Control Lines---Feet

S_M = Wing Area of Model---Square Inches

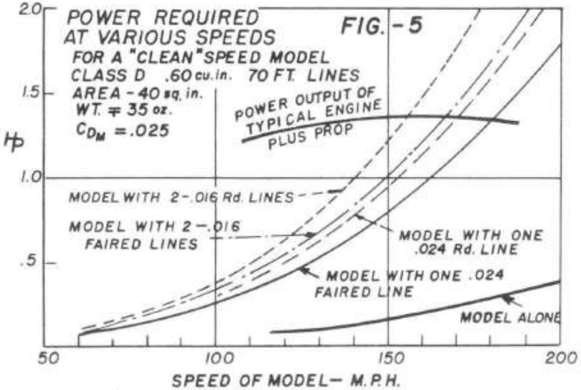
η = Propulsive Efficiency---.70 to .80

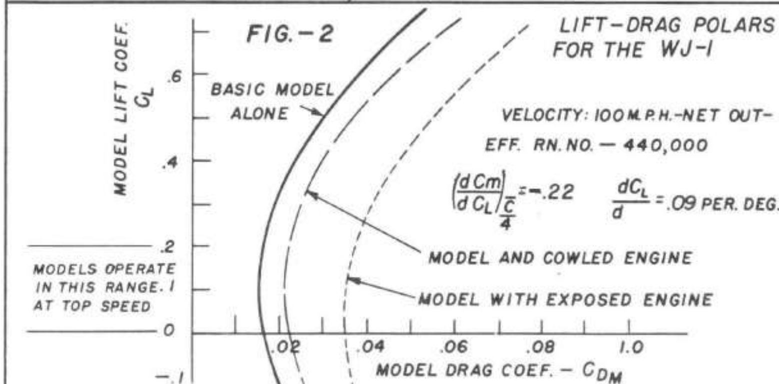
V = Velocity of Model---Miles per Hour

C_{D_L} = Coefficient of Line Drag (Use 1.0 for round wire or see Fig.4)

C_{D_M} = Coefficient of Drag of Model (Use .035 for exposed engine) (Use .025 for cowled engine) See Fig.2

ρ decreases on hot day by $\dfrac{520}{460 + (\text{Temp.°F})}$





Andrews

30-Min. Indoor

This plane was designed to resist the torque and weight of one loop of 1/16" x 1/30" rubber 15" long. To do 30 minutes with 2,000 turns in the motor we had to keep the wing loading as low as possible. Experience dictated a total weight between .062 and .068 ozs., a propeller rpm of 60 to 65.

Selection of materials for this model was a painstaking task and resulted in numerous experiments since balsa wood for indoor building purposes varies in weight from 3½ to 7 pounds per cubic foot. Although the strength is supposed to vary in direct proportion to the weight there is a difference in grades, in seasoning, in grain structure, and in the way the balsa is cut that increases or decreases its strength to weight ratio.

For these reasons sizes of component parts on the plan are only approximate, since the exact sizes I used would be too weak unless you work from identical sheets of wood. If you wish to duplicate the model the best procedure is to use those sizes of wood which would enable you to match the weights shown on the plan. Even if you can't match the weights you will still have a basic model which you can improve as you continue to build. It is stable and easily adjusted and capable of good flights. The weight of the rubber should equal the weight of the bare plane. For example, a plane weighing between .030 and .045 ozs. can be flown on 1/16" rubber; a plane weighing between .045 and .055 ozs. can be flown on 5/16" rubber; a plane weighing between .055 and .080 ozs. can be flown on 3/32" rubber.

The strength of each part must be sufficient to resist the torque of a fully wound motor, and strong enough so there will be no "flapping" or erratic behavior during flight. The plane must be stable during all phases of the flight, otherwise you lose seconds, even minutes, in flight time. Any altitude lost after the initial climb (which should be smooth) can never be regained. The microfilm used for covering is very important. When covering very light frameworks you will find covered parts warping and tending to pull outlines out of shape unless your film is absolutely dry and stable. I learned from bitter experience!

I use a microfilm solution with a minimum of dry plastisizer in it, so that my film will dry loose on the hoop in two days. After covering, I hold the wet wing and tail surfaces flat on a board until dry to prevent any warping before the job of final assembly is tackled.

In building the propeller use the thinnest outline you can to avoid distorting the pitch. Be sure the spars are straight by sighting from the end when inserting the ribs. The motorstick was formed around a 5/16" diameter dowel, wrapped with Silkspan tissue. It was baked in an oven at 450 degrees for five minutes. The tailboom was made in the same manner except it was formed around a balsa rod that tapered from 5/16" diameter at one end to 1/16" diameter at the other.

The wing stilts or pegs should be a tight slide fit into the sleeves of the motorstick, since incidence changes are made by raising or lowering these stilts. If they are not tight you will never maintain an adjustment unless you glue them in—then how would you get them out?

I would suggest that cardboard template forms be made for each part of the plane if you are interested in accuracy, symmetrical outlines, ease of duplication, and a faster method of construction.

ADDENDUM to NOTES ON RADIO CONTROL

by Dick Schumacher

Flight technic is a story in itself. A beginner just has to make the "beginning." By using a self neutralizing escapement the model will not "freeze" in a spiral dive and chances of getting the ship back are good. But do not let it get too high. Actually, there is little danger if the model is lined up properly before the flight. If you can find a 10 ft. bank, glide the model from it and check for smooth fast and straight glide. Or you can do likewise on a level ground. After you have the model up you can start on the fine trimming by watching its behaviour.

JIM HORTON---WAKEFIELD MODEL----This model is a solution of two problems inherent in folding prop models. One problem is the lack of reserve stability in the glide, and the other is the poor " to the last turn" climbing ability. Both of these problems are caused by increased glide velocity due to decrease of drag of the folder.

In developing this design a series of tests were made with freewheeling and folding props. With the C.G. and incidence setting fixed, the folder had a much higher velocity than a freewheeler, and its glide time would naturally be higher. To bring the freewheeler to its best glide trim, 2^0 more wing incidence was required. This can be attributed to the fact that freewheeler glide slower and required more incidence to develop same amount of lift as a folder does at higher speed but lower incidence.

Test flights proved that the freewheeler had a superior climb, in a sense that it reached higher altitude with the equivalent power. This, also, is directly connected with the glide setting. The free wheeler, being rigged for a very slow glide needs much less forward velocity for level flight or climb than does the folder. This is especially advantageous after high burst of power is gone and the model is working on the ver diminishing power curve. Under low power considerable incidence is needed if the model is expected to keep on climbing. It then becomes apparent that to obtain a climb with a folder equal to that of a freewheeler, we should change incidence during flight to bring about conditions which will favor the folder as they do the freewheeler.

The system shown elsewhere has been thoroughly tested on an old model. As it can be seen, under power the stabilizer angle is decreases 2^0, and brought back to 0^0 for glide when the power is out and the prop folds. The fact that both operations are tied to the same " release" takes care of the C.G. changes. Although it is our belief that the effect of the C.G. shift due to folder is negligible in relation to the changes of velocity and angular inertia as will be shown below.

The lack of reserve stability in the glide when a folder is used can be shown as follows: A rubber powered model has almost 50% of its weight in rubber which is distributed over the length of the fuselage. If a disturbing force induces a pitching moment the model has high angular inertia, and large corrective force is needed. If the speed is low as it is when the freewheeler is used, the problem is reduced. In order to produce a model with a folding prop that will have ample stability, we used a tail boom approximately one half of the hook to hook distance. This arrangement also improved power flight by having the model recover well from steep climb altitude.

The model shown has not yet been opened up due to cold weather, but it does consistant three minutes flights on 50% of turns (600). And the model climbs until the prop stops and it floats like a " Floater". The glide is made in large circles.

JOSEPH BOYLE----WAKEFIELD MODEL----The model flies in medium right circles and has a slow but steady climb. The large prop (20" dia.) turns over for 55 to 70 seconds and provides climb until the last 15 seconds. Despite the large diameter of the prop, the model is extremely stable under power and will perform very good in all kinds and types of weather. However, despite keeping the prop blade weight down as much as possible there is still a slight shift of C.G. position when the blades fold. This, combined with a shift in the motor C.G., will sometimes upset the trim.

The airfoil is one designed by Gail Cheesman, an old time model builder and now an aeronautical engineer with several years of experience at N.A.C.A.'s airfoil tunnels. (Two Dimensional and Variable Density) Gail has worked up a theory with a lot of proof behind it that an airfoil should be designed with both aspect ratio and chord being deciding factors in plotting the sections. All of his sections for Wakefield models have been plotted around a circular chord line and are plotted for a definite aspect ratio. The first one I used was on my 1949 Wakefield, and I believe that it did influence the performance of my model. Gail and I are both advocates of covering with sheet balsa the top 30% of the leading edge. This improves the airfoil performance as well as strengthens the structure.

The prop is a modification of a design by C.C. Johnson. I wanted the largest diameter prop I could possibly swing with 14 strands of 1/4 rubber. My theory being the old one that the larger the diameter, the more efficient the prop. I varied from 18" dia. 22" pitch to 22" dia. and 30" pitch. My final choice for the power used was 20" dia. and 28" pitch. I also believe that the greatest area of the propeller should be located as far from the hub as possible. This, of course, makes a rather low pitched prop the only solution.

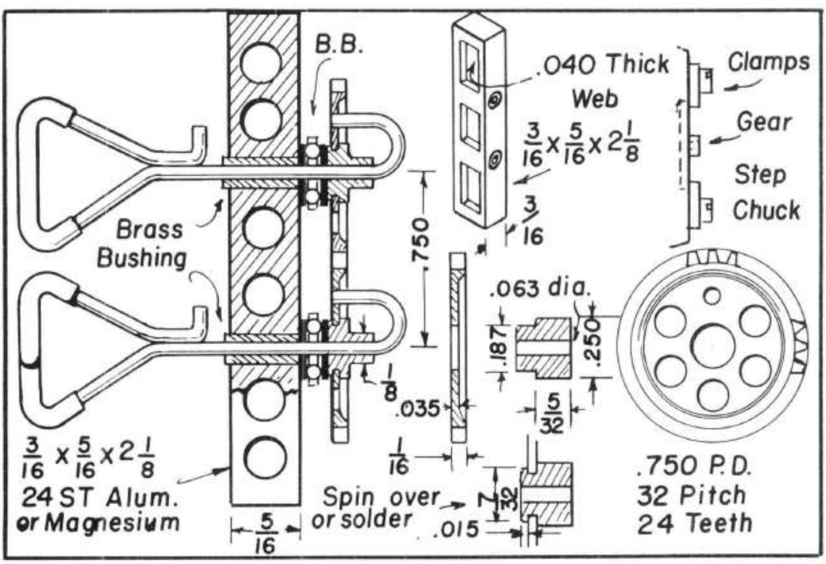
The peculiar shape of the blank results in a prop which, although low pitched, provides an ample bite into the air with sufficient blade area to give high thrust with minimum amount of rubber. The blades are thin and flex under power like an indoor prop. This provides a slight control over the R.P.M. and gives a more constant thrust. The prop airfoil is slightly cambered for strength rather than for efficiency. In an effort to decrease the drag of the prop blade near the hub, the angle of attack was greatly increased. (Most props carved do not take this drag area into consideration. In other words, the blade area near the hub turns over too slowly to bite the air properly and actually has a negative angle of attack relative to the speed of the air passing the model.)---Since I have been using this prop I believe that my average altitude per flight has increased between 50 and 100 feet.

Best time for the model is just a bit over 13 minutes for 3 flights under 5 minute maximum per flight conditions.

WAKEFIELD GEARS----THOMAS E. MURPHY----The first requisite of an efficient gear installation is a mounting that will not flex under load thereby causing binding of gears and excess friction. These mountings may be of many different types to fit the builder's particular model. Ball thrust bearings are a necessity to take the load of Wakefield motors. The use of brass bushings for the shafts is recommended although shafts running in 24 ST Aluminum and well oiled is a satisfactory substitute.

The gears used in the writer's installations are stock sheet brass spur gears of 32 Pitch, 1/16" face, 24 tooth and with a pitch dia. of .750". These gears when purchased have a .1875 bore and require a bushing to take a .063 shaft. "S" type hooks are recommended to prevent the rubber motor from climbing over the hook. It is important that the gear bushing be accurately machined as the true running of the unit depends on these parts. Face run out can be tolerated but diameter off center must be avoided. The writer's first rough machines the bushing .010 oversize with a shaft hole size of .063. A stub arbor is then turned on the lathe and bushing mounted and turned to a press fit in the gears which have a slight countersink on one side. The assembly is then mounted in a collet and the bushing spun over with a ball end tool. This procedure has been found superior to other types of installation. A press fit bushing soldered is a satisfactory substitute. Lightening holes and shaft lock hole are then drilled, the assembly mounted in a step chuck bored to take the outside diameter of the gear and the lightening section and hub faces turned to size.

The gears are then assembled with the bearing and shafts to the mount and the ends of the shafts bent into the locking hole and soldered in place. Gears are locked for winding by inserting a 1/16" wire pin through the eyes. Each motor is then wound the same number of turns and the wire pin removed. Short test flights may be made by leaving the pin in place and using the prop motor only.



OFFICIAL RESULTS
1951 WORLD CHAMPIONSHIP COMPETITIONS

WAKEFIELD CUP—July 7th and 8th—Jami-Jarvi, Finland

1st, St. Stark, Sweden, 705.2 sec. 2nd, H. Tubbs. Gt. Britain, 676.2 sec.

SWEDISH CUP—Aug. 22nd—Bled, Yugoslavia

1st, Oscar Czepa, Austria, 871 sec. 2nd. Petkovsky, Yugoslavia, 800 sec.

ENGINE POWER—Free Flight—July 15th, Eureux, France

1st, G. Schmid. Switzerland, 600 sec. 2nd, Lauchli, Switzerland, 545 sec.

ENGINE POWER—Control Line—July 28, 29 and 30, Knokke, Belgium

Speed Class I (2.5 cc max.)
1st, A. Hewitt, Gt. Britain, 151 km/h
2nd, P. Wright. Gt. Britain, 124 km/h

Speed Class II (5.0 cc max.)
1st, P. Wright, Gt. Britain, 201 km/h
2nd, Kreulen, Holland, 185 km/h

Speed Class III (10 cc max.)
1st, Labarde, France, 204.6 km/h
2nd. Laniot, France, 194.1 km/h

Acrobatics (3900 pts max.)
1st, A. Hewitt, Gt. Britain, 3,200 pt.
2nd, Vallez, Belgium, 2,779 pts.

Note. Wakefield, Towline Gliders and Free Flight Engine Power flights are timed to 5 min. max. Duration total is for "Three Flights." Speed given is an average of two runs.

F.A.I. RULES FOR INTERNATIONAL MODEL AIRCRAFT COMPETITION

Wakefield Cup — Rubber Power

Total surface area between 263.5 and 294.5 sq. in. Minimum fuselage cross section area 10 sq. in. Minimum total weight 8.113 oz. Rise off Ground.

Swedish Cup — Towline Gliders

Total surface area between 495.3 and 526.3 sq. in. Minimum fuselage cross section=Total Area/100. Minimum weight 14.5 oz. Maximum towline 100 meters.

Engine Power Free Flight

Maximum engine displacement 2.5 c.c. (0.15 cu. in.) Minimum weight 200 grams per cu.cm. of engine displacement. Minimum surface loading 12 grams per sq. dcm. (2.75 oz. per 100 sq. in.) Fuselage cross section=Total Area/80. Rise off Ground.

NOTES: Total area includes wing and stabilizer. Area is assumed to be effective area or "look down," interruptions in the surface to count as area. Flights limited to five minutes. The final score to be average of three flights.

Control Line

No specific rules as yet. Classified according to engine displacement in speed, and on points for stunt.

THE INTERNATIONAL F.A.I. CHAMPIONSHIP PROGRAM

by Henry Dore

For some time now, model builders interested in the International aspect of the hobby had hoped and called for a program of annual contests which would officially determine the World Champion of a particular category of models now being built.

The first active step was taken by the F.A.I. in 1950 when it recognized the Wakefield Cup competition as the official World Championship meet for rubber powered models; The Swedish Cup as the Championship event for towline gliders; and the control-line competition held annually at Knokke, Begium, as the official trials for the Control-Line Championship. There being no ready made formula for engine powered free flight models, the rules mentioned elsewhere were adopted, and the first meet to this standard was held in France in 1951.

The next phase of this program must become something more than just the "official." Model builders throughout the world must back it up with active participation. Such active participation would naturally raise the prestige of the program. The 1952 season will see a greater participation in all divisions than heretofore.

The question of supporting this Championship program, and the whole matter of our active participation in the F.A.I. world affairs is a difficult challenge to the American modeller. We have in the past found it very difficult to send one team to Europe to the Wakefield competition. What now, with four annual events on the schedule? Also, so far we have not understood F.A.I. matters, and until recently did not take much interest in them. Do you feel that it is time we did?

There are many who feel that there is little reason for our participation in the F.A.I. meets. They feel that we in the United States should put on the championship meets, especially in Control-Line and Gas. "Let them come if they think they can beat us,' would seem to be the slogan.

There is little need to present here a detailed argument against such an isolationist attitude. It would be too bad for us to act that way. The Europeans simply cannot come here for model airplane competitions. We would be losing a great deal of prestige. We must also not forget that the Europeans have come to their own in all phases of the hobby (including Control Line). It is they who may well say "We'll take you on! Come on over!" At least for the present we must realize nothing truly International can come out of an American attempt to organize a World Championship program. The Wakefield experience backs this up well. Has not that competition fallen into a slump (from the point of view of participation) everytime it was held in America?

As we have seen. the present F.A.I. program calls for four different annual Championships. It has already been suggested, and this would seem a logical development, that these four contests be held together in a sort of "Internationals" or "Model Olympics." Since the greatest value of Championship meets is the exchange of ideas among the expert builders of different nations, at "Model Olympics" gathering would certainly be a very great step forward for our hobby.

These "Internationals" would not need to be annual affairs. In fact, much would seem in favor of the event being held but every other year or even every three years. This would help make it possible for more nations to attend. We have, for instance, been spending approximately $6,000.00 a year on the Wakefield team. In the case of the "Olympics" we would have $12,000 (or $18,000) available for sending a team.

Linked with the "Internationals" would be the session of the F.A.I. model commision. Separated from the larger, full size aviation meetings, the commision could probably work more effectively. It would be meeting in close contact with the world's best builders which would be of great help in deciding such matters as new rules. The F.A.I. model commision would become directly controlled by model builders. Finally, the meeting of the commision at the same time as the "Internationals" would solve for many countries the problem of sending representatives. There would surely be some builders in their respective teams to represent their country at the meeting.

Such an "Olympic" program organized by the F.A.I. can become a reality in 1953. We had instructed our representative to support such a plan at the Bruxelles meeting, 1951. — We must keep up the pressure but this time also prepare a more definite plan for our representative to submit to the commision.

For 1952, the Championship program will be the same as in 1951, but should take on more importance. Our A.M.A. Wakefield Committee has already made definite plans for sending a team to Sweden. It now seems impossible to organize other committees in an attempt to form teams for the other events. Perhaps one of the other Championship meets will be held at a date close enough to the Wakefield to enable some of our representatives to take in both events. This worked out well last year in Paris.

We must not overlook the possibility of Proxy flying. We can send models to be flown in the control-line meet (speed), Free Flight Gas and Towline Championships of 1952. Doing so would mean a great deal in showing the rest of the 'model' world that we are interested and willing to support the F.A.I. Program. It would seem that we would be particularly interested in participating in the Gas Model event, which will be held in Switzerland. After all, the gas model is almost an exclusive American development, and this type outnumbers by far any other type in this country. Another reason is that we were already represented in 1951.

Proxy flying can be effective and we should not hesitate to rely on it if we cannot finance the teams. (The Wakefield and Moffet Cups have both been already won by proxy flying.) Since it seems now impossible to hold eliminations for 1952 Proxy teams, the simplest way would be to have the A.M.A. select the team from the outstanding builders who may be interested, or use the results of last year's Nationals in the selection. At any rate, all models sent to the International F.A.I. meets must have the O.K. of the Academy if they are to represent the U.S.A.

As we begin an active cooperation with the F.A.I. we will need a sort of "Foreign Affairs" committee which will be responsible for organizing eliminations, raising funds, liaison work with the F.A.I. etc. It is quite a job. The financial aspect of the plan would seem colossal, judging by the effort that has to be made to finance the Wakefield team. Perhaps the fact that the "Internationals" will cover the entire range of model building the industry might feel more responsible in its obligation to its multi-million dollar customer.

There is a long road ahead in the development of model building on the International level. At home, much progress has already been made, chiefly in the attitude of our model leaders towards such developments. The door is now finally opened for progress. Our A.M.A. has already done much to link us closer to the other countries, so let us keep the ball rolling in 1952.

A/2 RUBBER POWER

by H. Dore and C. Curry

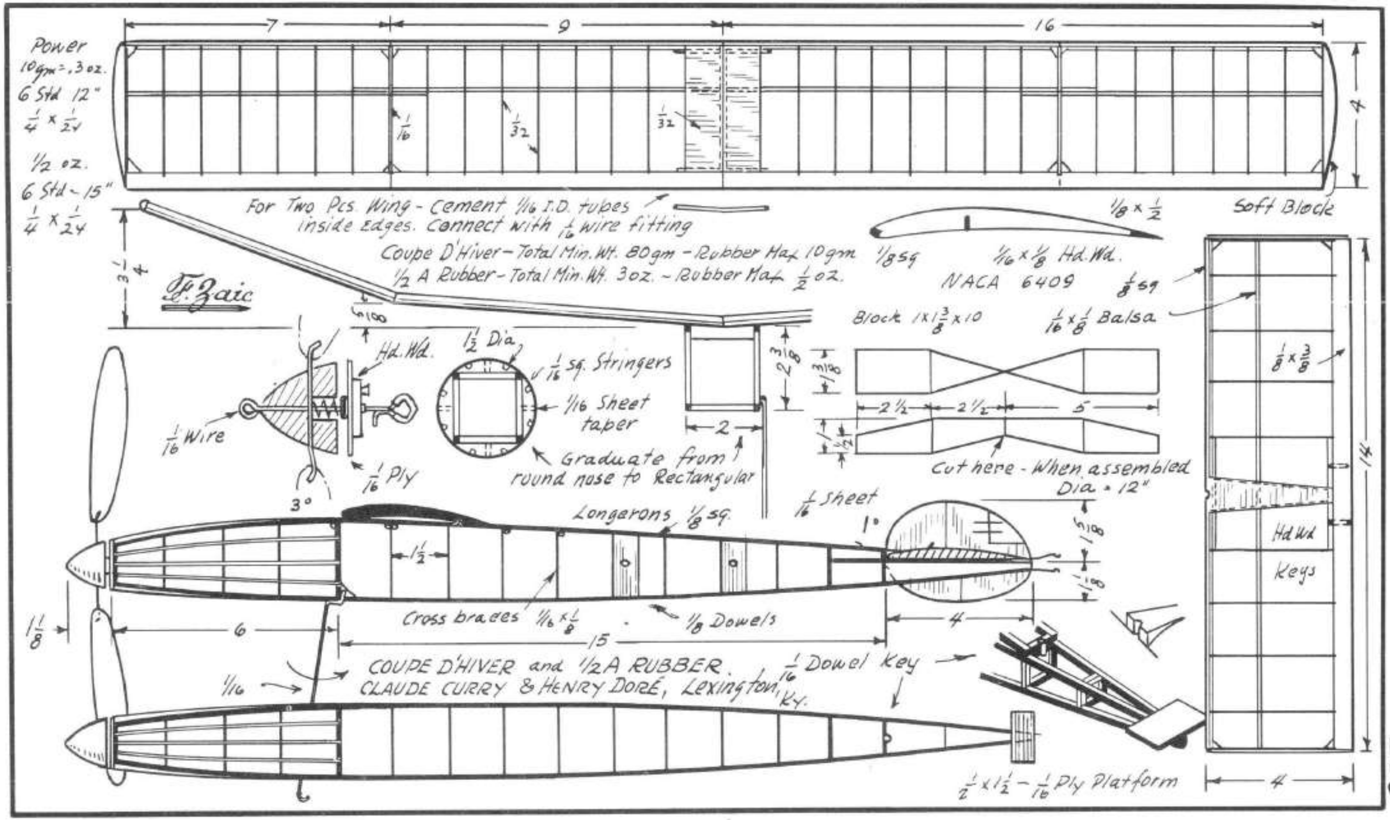
Two years ago we sent four models to Paris to be flown by proxies in the "Coup d'hiver." We did O.K. since our proxies were able to place our models 4th, 5th and 6th, and win for us the team award.

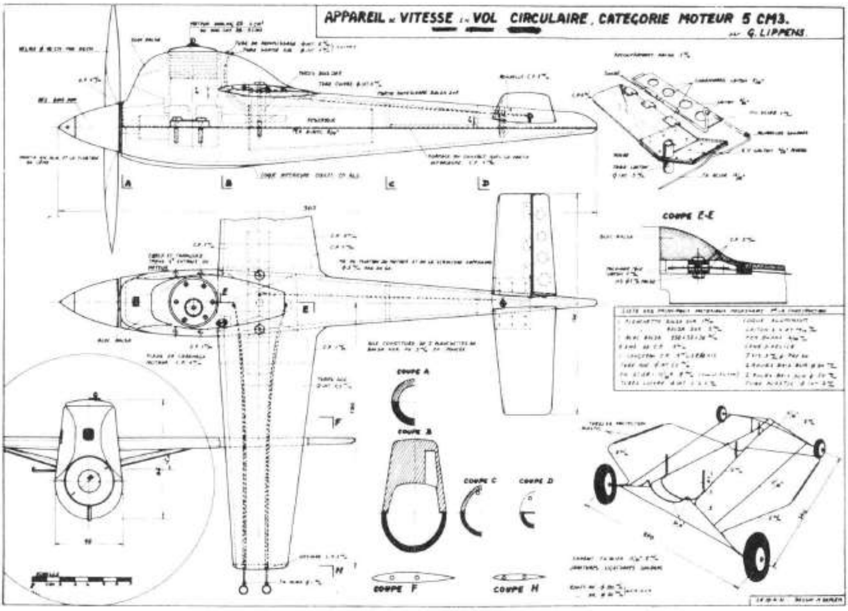
We became very much interested in these "Coup d'hiver" models because of the sort of flying they would give us. With the small amount of rubber allowed in proportion to the total weight, (10 grams of rubber for 80 gram model) they were not overpowered nor were hard to fly. Then, due probably to their small size, we found them to be almost "unbreakable." We also found these models to be ideal for the beginners.

Claude's younger brother, Jim, who is but 13 years old, inherited our original experimental model. It was with this model that he learned about flying rubber models. He must have learned well for he became a sharp contest flyer. He had many wins this past season and was 4th at the Atlanta Wakefield eliminations.

We had advanced, two years ago, the idea of A.M.A. adopting rules of this type. That is, to limit the amount of rubber used. Since it is not advisable to change rules completely overnight, it is hoped that other model builders will try this type of models and find out for themselves what can be done.—Suggested rules for the A/2 Rubber Model are as follows: Maximum weight of rubber ½ oz. Minimum total weight of model 3 oz. Fuselage cross section; Length 2/200. Rise off Ground required. And a 2 minute flight limit with average of three flights to count for score.

The model shown is the 8th of this type. As a A/2, it averages about 1 min. 30 sec. We have found that models of this type can be flown in very small fields. Rules allow models of pleasing line, and bring contest model experience to beginners and the average builder. It is quite possible that by having models which can be flown easily we will gain many more active contest fliers.


Power
10gm=.3oz.
6 Std 12"
1/4 x 1/24
1/2 oz.
6 Std - 15"
1/4 x 1/24
7
9
16
4
1/16
1/32
1/32
For Two Pcs. Wing - Cement 1/16 I.D. tubes
inside Edges. Connect with 1/16 wire fitting
1/8 x 1/2
Soft Block
Coupe D'Hiver - Total Min. Wt. 80gm - Rubber Max 10gm
1/2 A Rubber - Total Min. Wt. 3oz. - Rubber Max 1/2 oz.
1/8 sq
1/16 x 1/8 Hd. Wd.
NACA 6409
1/8 sq
3 1/4
F. Zaic
6/100
Hd. Wd.
1 1/2 Dia.
1/16 sq. Stringers
1/16 Sheet taper
1/16 Wire
1/16 Ply
Graduate from round nose to Rectangular
2 3/100
2
Block 1x1 3/8 x10
1/16 x 1/8 Balsa
3/100
2 1/2
2 1/2
5
1/2
Cut here - When assembled Dia = 12"
1/8 x 3/8
14
3°
Longerons 1/8 sq.
1/16 Sheet
1°
6/100
1/100
1 1/2
Cross braces 1/16 x 1/8
1/8 Dowels
Hd Wd Keys
1 1/8
6
15
4
COUPE D'HIVER and 1/2A RUBBER.
CLAUDE CURRY & HENRY DORÉ, Lexington, Ky.
1/16 Dowel Key
1/16
2 1/2 x 1 1/2 - 1/16 Ply Platform
4



JOHN KIENER:---ASYMETRICAL THRUST--- The off center thrust line tends to turn the model to the right, this is compensated by a lot of left rudder. The wing is not washed in or out.---The flight characteristics are most satisfactory. Under low power the model climbs in a tight left circle. Spiral dives are prevented by the thrust line position below the Center of Drag (when the model is in a left bank). Under medium power the ship climbs straight out at a 45^0 angle of climb. When high power is applied, a tight right turn results. The left rudder keeps the tail low. Loops are impossible because the offset thrust pulls model into a right circle if it attains enough speed to reach a critical position. The glide pattern is a very tight left circle.

AIR TRAILS 304 East 45th St. New York 17, N.Y.	MODEL AIRPLANE NEWS 551 Fifth Avenue New York 17, N.Y.	AERO MODELLER Allen House Newarke Street Leicester, Eng.	MODEL AIRCRAFT 23 Great Queen St. London, W.C. 2 England
FLYING MODELS 215 Fourth Ave. New York 3, N.Y.	AUS. MODEL HOBBIES 3 Percival Street Glenelg, So.Australia	MODEL AVIA 1 Rue Montoyer Bruxelles, Belg.	MODELLISMO Piazza Ungheria 1 Rome, Italy

CONTENTS

CONVERSION TABLES

2.54 x In. = Cm.	28.35 x Ounces = Grams	0.68 x Ft.Sec. = M.P.H.
.394 x Cm. = In.	.0355 x Grams = Ounces	1.467 x M.P.H. = Ft.Sec.
6.45 x Sq.In. = Sq.Cm.	16.4 x Cu.In. = Cu.Cm.	.011 x Ft. Min. = M.P.H.
.155 x Sq.Cm. = Sq. In.	.06 x Cu. Cm. = Cu.In.	88 x M.P.H. = Ft. Min.

Dear Friends:

Writing this book was easy in one sense, and extremely difficult in another sense. Most of you have been very helpful in supplying plans and information to the best of your ability, and without the slightest thought of payments. And it was this sort of a cooperative feeling that helped me overcome the difficult side of writing this book. This difficult side is more or less personal, but I will be glad to tell you all about it when I see you.

After rewriting and regrinding pages and pages, and drawing up so many plans, I may have lost the perspective on the material in this book. Therefore, I would appreciate if you would let me know if this book answers some of the questions which have been bothering most of us.--I must confess that in many cases I do not know the exact answer, but I tried to present the problems so that some of you may help me find the true answers. (Incidentally, what happened to all of those model builders who became aeronautical engineers? We were counting on them for a lot of answers.)

About the future? Who can tell. In the meantime, when you fly your model, watch it carefully. Does it seem to follow any of the patterns described in this book? If it does follow a book pattern, how close are the design characteristics of your model and the basic model described in the book for that particular pattern? Here is where you can help me out more than you know. Let me know how close is the information in the book to the actual field practice.

It is quite possible that future books will be coming out more regularly. We have now the basic structure. All we have to do is to build on it.---So, keep notes on your flights. If you have a model that you would like to show to the rest of us, let me know. Also, if you see someone else flying an exceptionally fine model, would appreciate knowing about it.------And so, until next time; "May the Thermals be at your beck and call!"

Frank Zaic

P.S. I have quite a problem in how to let you know just how many persons helped in making this book possible. There were so many! Most of them you will find on the "Contents" page. But I would especially like to thank Carrie and Frank Haynes of New York City for proof reading the manuscript, and for making me feel that I am a "writer:" And H.A. Thomas of Little Rock, Ark., for so many fruitful "connections"; And Jean Guillemard of France for special "favors". To all who had helped, Thanks!