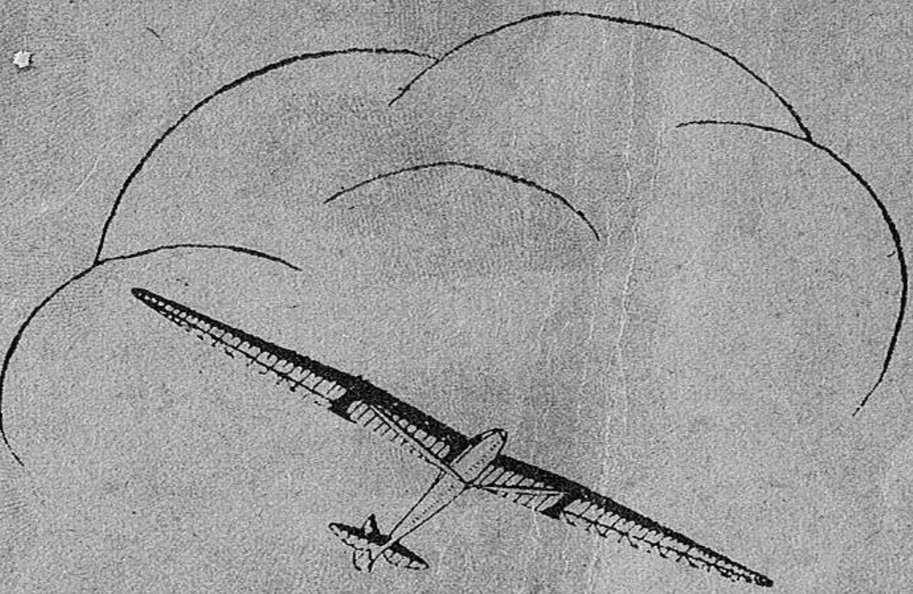


Price 1/6

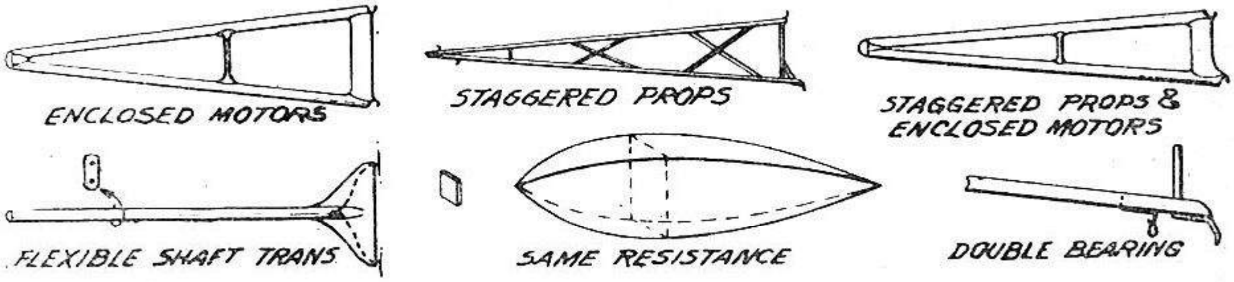
1936 Junior AERONAUTICS Year Book

Edited by IVOR FRESHMAN

TWIN PUSHER

The standard "A" frame with exposed rubber has a great deal of resistance and detracts from overall efficiency. Tubular and streamlined frames with rubber enclosed are much better. The sketches show several proposed designs which are not impossible to build: Consider them when building your next twin pusher.

Staggered props lower the triangular thrust line, but care should be taken that they do not hit each other. A double bearing, as shown, will do the trick.

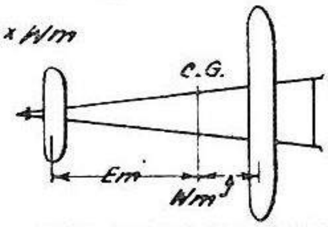


PROPORTION BETWEEN PUSHER SURFACES

The most important factor in the design of a twin pusher is to have the proper proportion between the surfaces--wing, elevator and tailplane, if used. The following formula can be used for ships already built, to minimize test flights, and to check the placement of surfaces so as to give the most efficient results:

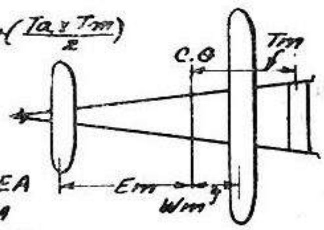
$$Ea \times Em = Wa \times Wm$$

Ea = ELEV'T AREA
Em = " ARM
Wa = WING AREA
Wm = " ARM



$$Ea \times Em = (Wa \times Wm) + \left(\frac{Ta \times Tm}{2}\right)$$

Ea = ELEV'T AREA
Em = " ARM
Wa = WING AREA
Wm = " ARM
Ta = TAILPLANE AREA
Tm = " ARM



Only half of the tailplane product is used as the tailplane works in disturbed air.

FINDING THE CORRECT ELEVATOR AREA WHEN WING AREA IS KNOWN

Make the complete ship with the exception of the elevator. Assemble and place the wing at the most favorable spot, in respect to fastening, and distance from tailplane, if one is used. Place a weight equivalent to the finished elevator about 3" from the frame apex. Find the C.G. and use the above formulas, making E_a the unknown. The result will be the correct elevator area to use for that particular setting. But before you make the elevator, check it for the proper dihedral, which determines the position of Directional Center (D.C.). (The Directional Center is treated separately later on.)

The formulas given are fairly accurate regardless of which airfoils are used on the different surfaces, but if we want to be exact, when different airfoils are used, we should use this formula:

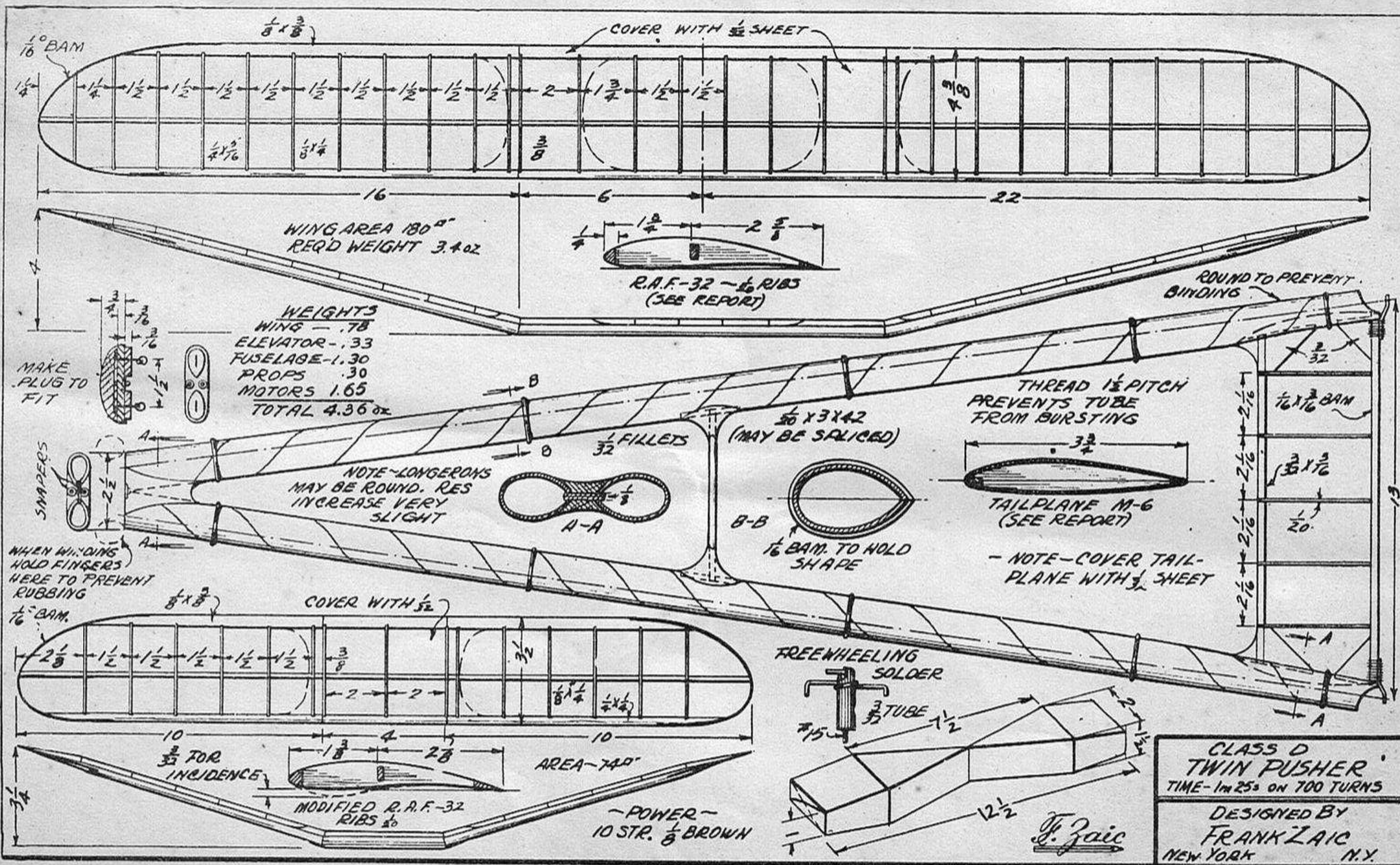
For model with wing and elevator only.

$$EC_L \times Ea \times Em = WC_L \times Wa \times Wm$$

For model with wing, elevator and tailplane

$$EC_L \times Ea \times Em = (WC_L \times Wa \times Wm) + \left(\frac{TC_L \times Ta \times Tm}{2}\right)$$

C_L is the lift coefficient of the particular airfoil used. The other factors are the same as in the other formulas. The calculations should be made with same incidence on all sections. The extra 2 or 3 degrees incidence of the elevator, when flying, will produce the arrangement that makes pushers so popular, namely, the elevator


CLASS D
TWIN PUSHER
TIME - 1m 25s ON 700 TURNS
DESIGNED BY
FRANK ZAIC
NEW YORK N.Y.
COVER WITH 1/32 SHEET
WING AREA 180 □"
REQ'D WEIGHT 3.4 OZ
R.A.F.-32 ~ 1/20 RIBS
(SEE REPORT)
ROUND TO PREVENT BINDING
WEIGHTS
WING — .78
ELEVATOR - .33
FUSELAGE - 1.30
PROPS .30
MOTORS 1.65
TOTAL 4.36 oz
MAKE PLUG TO FIT
THREAD 1 1/2 PITCH
PREVENTS TUBE
FROM BURSTING
1/32 FILLETS
1/20 X 3 X 42
(MAY BE SPLICED)
NOTE ~ LONGERONS
MAY BE ROUND. RES
INCREASE VERY
SLIGHT
A-A
B-B
1/16 BAM. TO HOLD SHAPE
TAILPLANE M-6
(SEE REPORT)
- NOTE - COVER TAIL-
PLANE WITH 1/32 SHEET
SNAPERS
WHEN WINDING
HOLD FINGERS
HERE TO PREVENT
RUBBING
COVER WITH 1/32
3/32 FOR INCIDENCE
MODIFIED R.A.F.-32
RIBS 1/20
AREA ~ 74 □"
~ POWER ~
10 STR. 1/8 BROWN
FREEWHEELING
SOLDER
3/32 TUBE
#15
F. Zaic

stalling before the wing and keeping the plane on its best glide. It is a good idea to make several calculations (at different angles of attack) to find out just how the model might behave. Of course, the calculations should be made using the C_L of the elevator at its flying setting; that is, 2 or 3 degrees more than that of the wing.

ASPECT RATIOS, selection of airfoils, props, wing construction, and winding, will be treated under their respective headings.

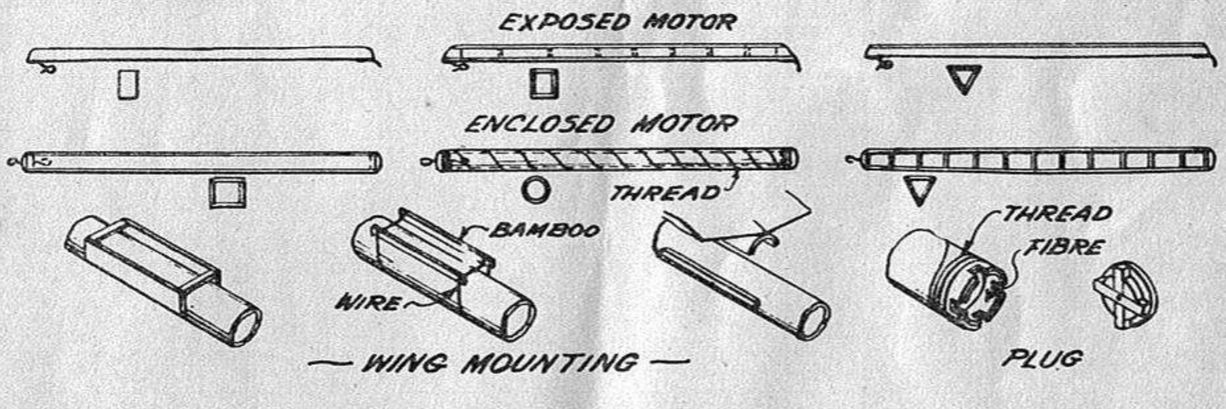
LAUNCHING TWIN PUSHERS

Stand in a walking position, back slightly bent, holding the model just above, and in front of your head. This posture permits you to swing the model over head and turn at the same time in case of a sudden gust. Launch by swinging your arms a little faster than the flying speed of the model. Do not hurl, as this will upset the model, and being close to the ground, it will not have time to recover.

When bringing back a model in a windy weather, hold it by the apex and let it swing behind your back, or hold the apex with the left hand and have the wing under your right arm.

SINGLE PUSHER

The same rules that were given for the twin pusher are applicable to the single pusher. The only difference between a twin and a single is the motor stick design, and the wing mounting. The drawing shows several types. A motor enclosed in the tube is the best as it offers the least resistance at all angles of attack. If you have to use rubber outside, use the built up design, as it has better anti-twist and anti-bending characteristics for given weight.

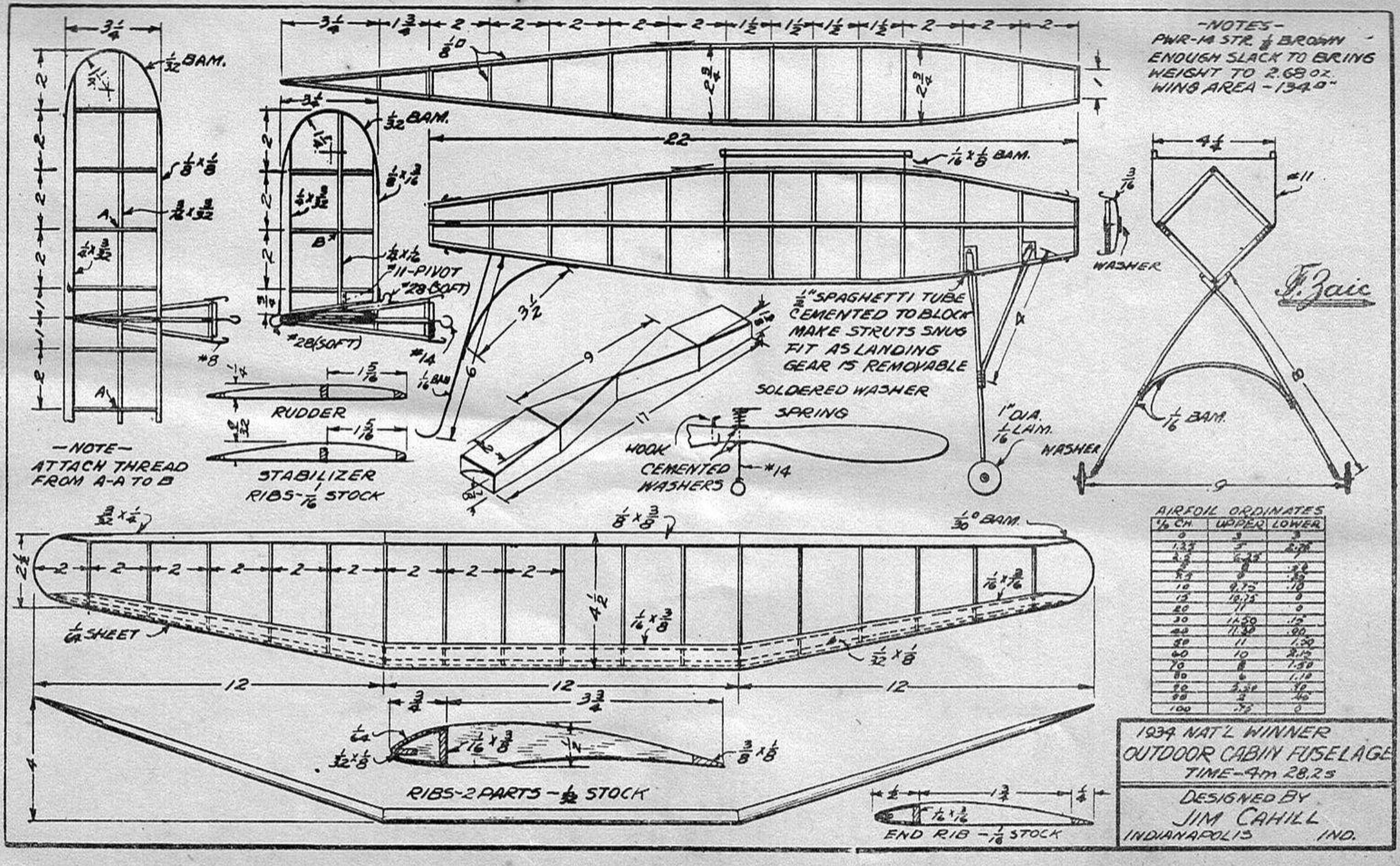


CABIN FUSELAGE

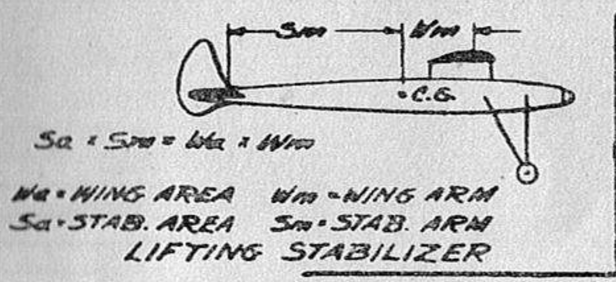
The name, Commercial, has been changed to Cabin Fuselage by the N.A.A., to differentiate between the scientific models and those built from commercial flying scale kits.

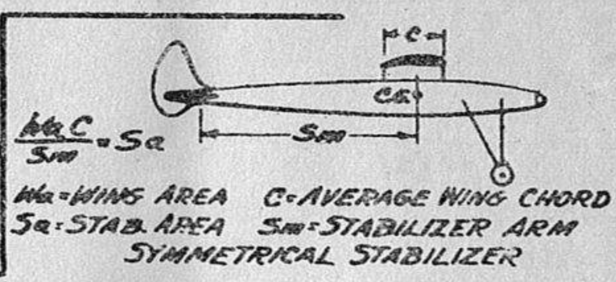
It is much harder to design a stable tractor than a pusher, because of the different surface layout. In a pusher, all the surfaces contribute lift, but in tractors the wing is usually the only support, the exception being the lifting tail design.

A lifting tail has an advantage over the flat tail in that it contributes lift. The same formula that is used in a pusher to find the elevator area, can be applied to the lifting stabilizer. When using lifting tails, be sure to have a high wing, or else the model will be unstable. A more complete treatise on this design is given in the Indoor Tractor Design.



-NOTES-
PWR-14 STR. 1/8 BROWN
ENOUGH SLACK TO BRING
WEIGHT TO 2.68 OZ.
WING AREA - 134 □"
1/32 BAM.
1/16 x 1/8 BAM.
-NOTE-
ATTACH THREAD
FROM A-A TO B
RUDDER
STABILIZER
RIBS - 1/16 STOCK
1/2" SPAGHETTI TUBE
CEMENTED TO BLOCK
MAKE STRUTS SNUG
FIT AS LANDING
GEAR IS REMOVABLE
SOLDERED WASHER
SPRING
HOOK
CEMENTED
WASHERS
1" DIA.
1/16 LAM.
WASHER
#11-PIVOT
#28 (SOFT)
1/16 BAM.
F. Zaic
AIRFOIL ORDINATES
% CH. UPPER LOWER
1/64 SHEET
1/30 BAM.
RIBS-2 PARTS - 1/32 STOCK
END RIB - 1/16 STOCK
1934 NAT'L WINNER
OUTDOOR CABIN FUSELAGE
TIME - 4m 28.2s
DESIGNED BY
JIM CAHILL
INDIANAPOLIS IND.



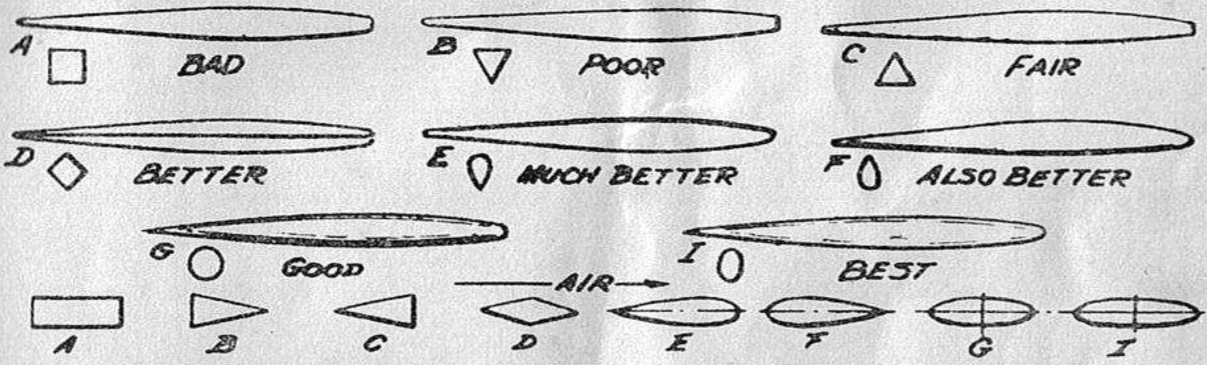


Up to date we have not found a practical, exact method for calculating symmetrical stabilizer area. The writer worked out an excellent rule which is simple, practical and approximately exact.

A lifting tail should have a negative incidence of 1 to 2 degrees. A symmetrical tail is best at zero degrees. These incidences are in respect to the thrust line. Actually the neg. incidence is about 1 or 2 degrees more, because of wing's downwash. You may use positive incidence in the tail, but you must increase the incidence of the wing so as to keep 2 or 3 degrees difference between them.

FUSELAGE

Most of the resistance in a Cabin Fuselage is in the body. Simple clean lines are the best. The drawing shows several designs and also their cross sections in relation to the relative wind when they fly at an angle



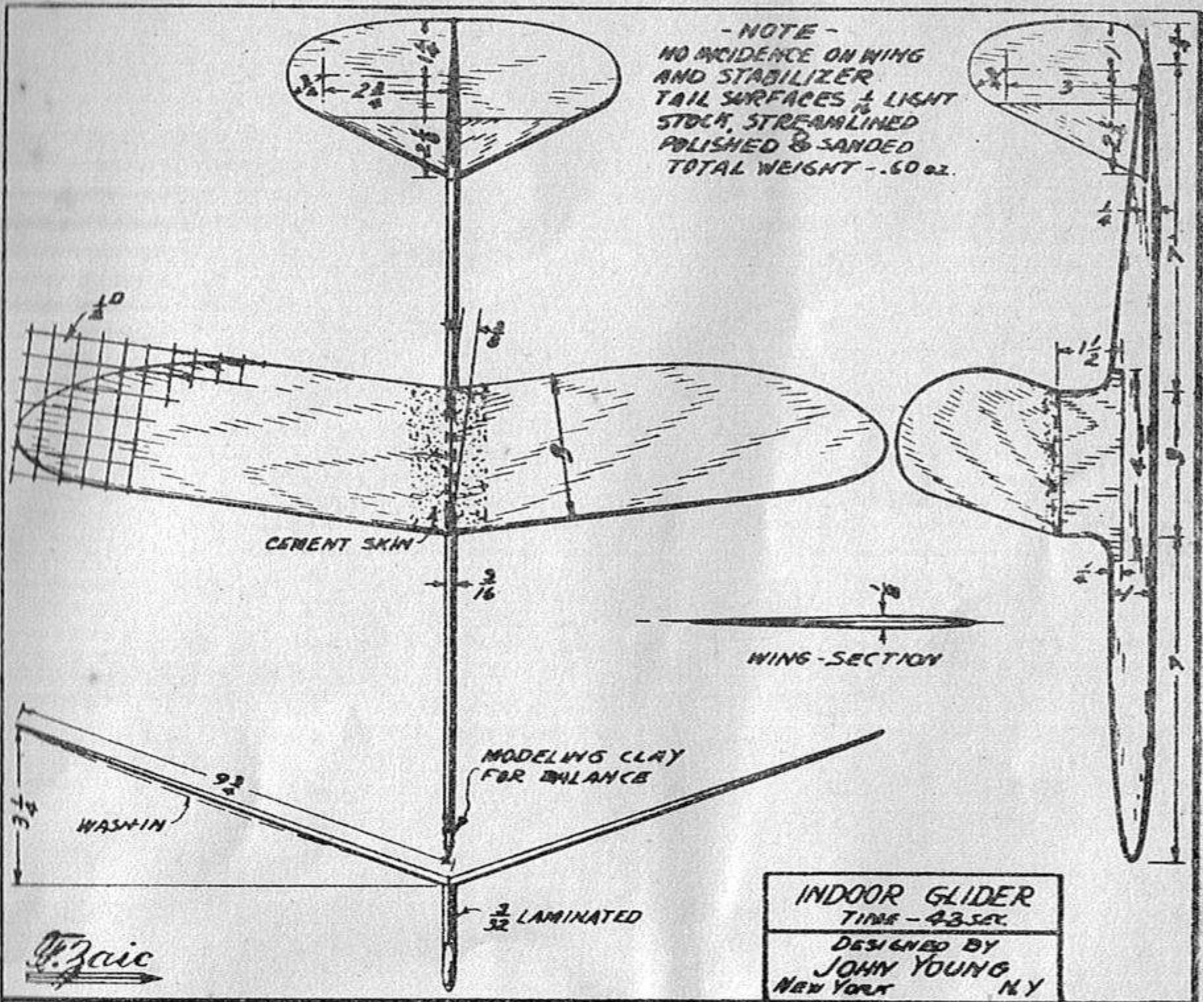
HORIZONTAL CROSS SECTIONS OF FUSELAGES INCLINED 15°

EFFECT OF ANGLE OF ATTACK ON FUSELAGE DRAG

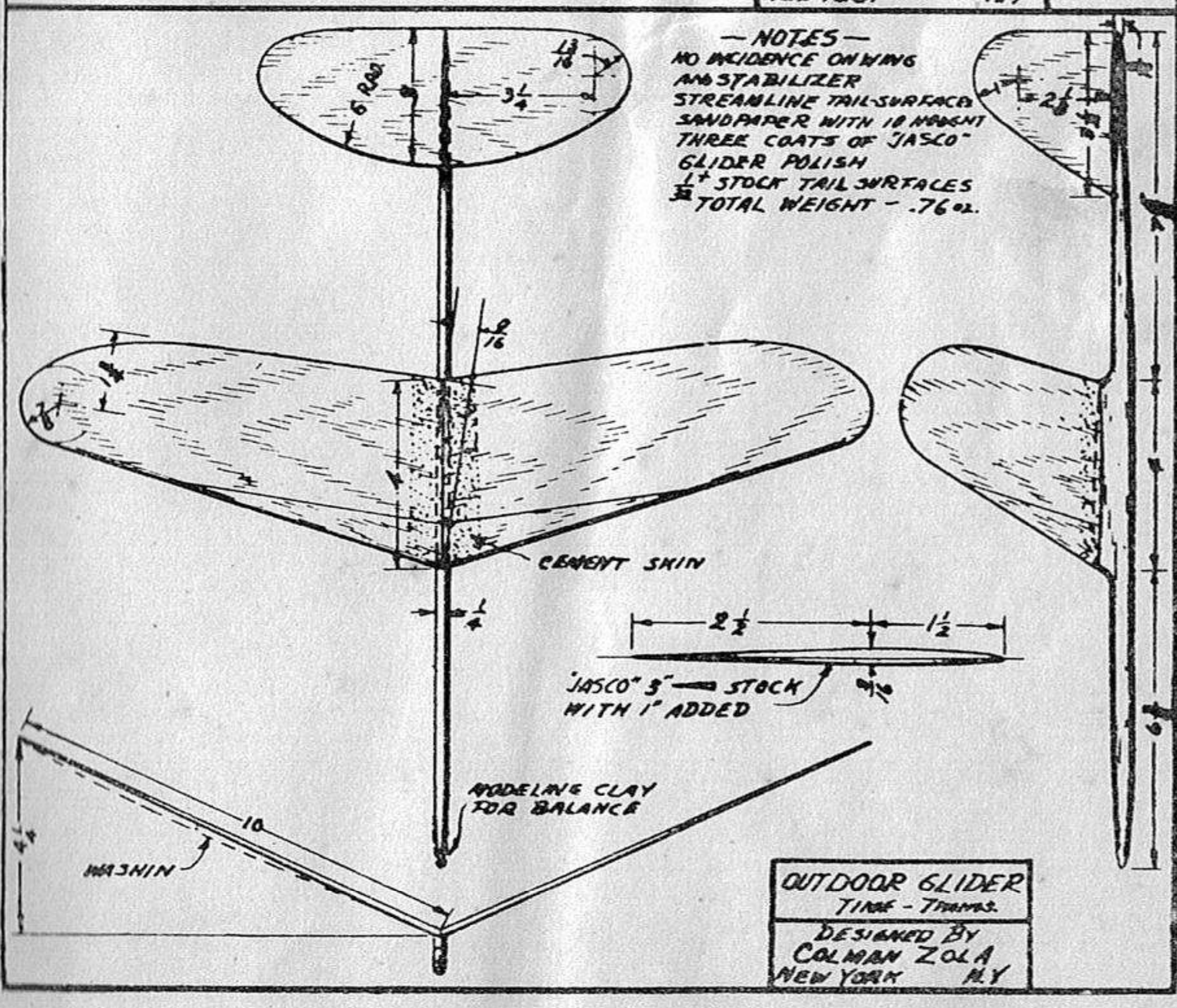
The drag of a fuselage with well rounded section does not change with increase of angle of attack. The drag of a fuselage with square or rectangular section increases with increase of angle of attack. The following table shows the drag, in pounds, of two fuselages, one square in cross section and other elliptical. Both have the same length and cross section area. (From 'Aerodynamics' by Diehl.)

Angle of attack	0°	5°	10°	15°	20°
Square Section	.050	.057	.070	.093	.129
Elliptical Sec.	.012	.012	.010	.014	.022

You can see from above drawings and table that it is a bad policy to point the prop down to obtain a high angle climb. The resistance overcomes all the benefits and actually makes it worse. A much better plan is to increase the angle of the wing and stabilizer and let the fuselage be horizontal in flight. The result is that the decrease of resistance speeds the model with consequent better climb, and on the glide the wing will work at its best L/D.



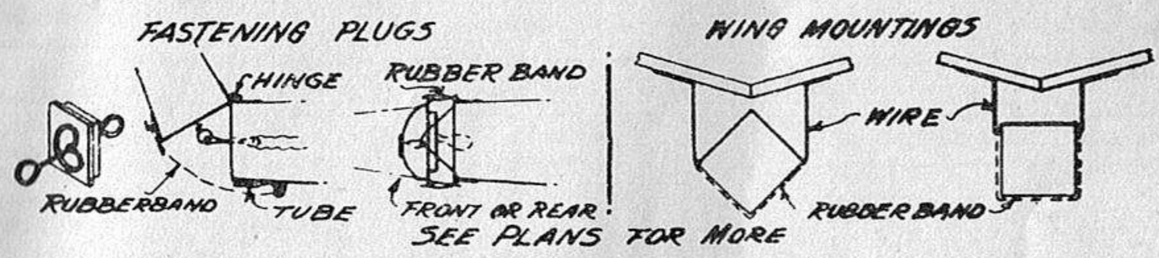
-NOTE-
NO INCIDENCE ON WING AND STABILIZER
TAIL SURFACES 1/16 LIGHT STOCK, STREAMLINED POLISHED & SANDED
TOTAL WEIGHT -.60 oz.
CEMENT SKIN
WING-SECTION
MODELING CLAY FOR BALANCE
WASH-IN
3/32 LAMINATED
INDOOR GLIDER
TIME - 43 SEC.
DESIGNED BY
JOHN YOUNG
NEW YORK N.Y



-NOTES-
NO INCIDENCE ON WING AND STABILIZER
STREAMLINE TAIL-SURFACES
SANDPAPER WITH 10 NOUGHT
THREE COATS OF "JASCO" GLIDER POLISH
1/32" STOCK TAIL SURFACES
TOTAL WEIGHT - .76 oz.
6 RAD.
CEMENT SKIN
"JASCO" 3" STOCK WITH 1" ADDED
MODELING CLAY FOR BALANCE
WASHIN
OUTDOOR GLIDER
TIME - 7 MINS.
DESIGNED BY
COLMAN ZOLA
NEW YORK N.Y

FUSELAGE CONSTRUCTION

A round monocouque construction is the best. It is not as hard to make one as it seems. The next best is to cover whatever fuselage you use with sheet balsa. The strength will surprise you! Paper covering is fair for flat surfaces, but poor for covering fuselages of round cross sections. The fuselage longerons should be of 1/8 hard balsa, but lighter if motor stick is used.



LANDING GEAR AND TAILSKID

Bamboo or wire--which shall it be? Both have their merits but a wire landing gear is more durable, and does not have to be removable for packing. Thin, laminated and elliptical cross section wheels are best. Do not use heavy wheels to get a low C.G. It is a makeshift way of obtaining stability. Keep away from thick pants. See the Cabin Fuselage plans for landing gear and tail skid designs. A long tail skid is best, because it presents the least frontal resistance of the model at the take-off.

WING CONSTRUCTION, and other factors dealing with general information will be found under their respective headings.

STICK TRACTOR

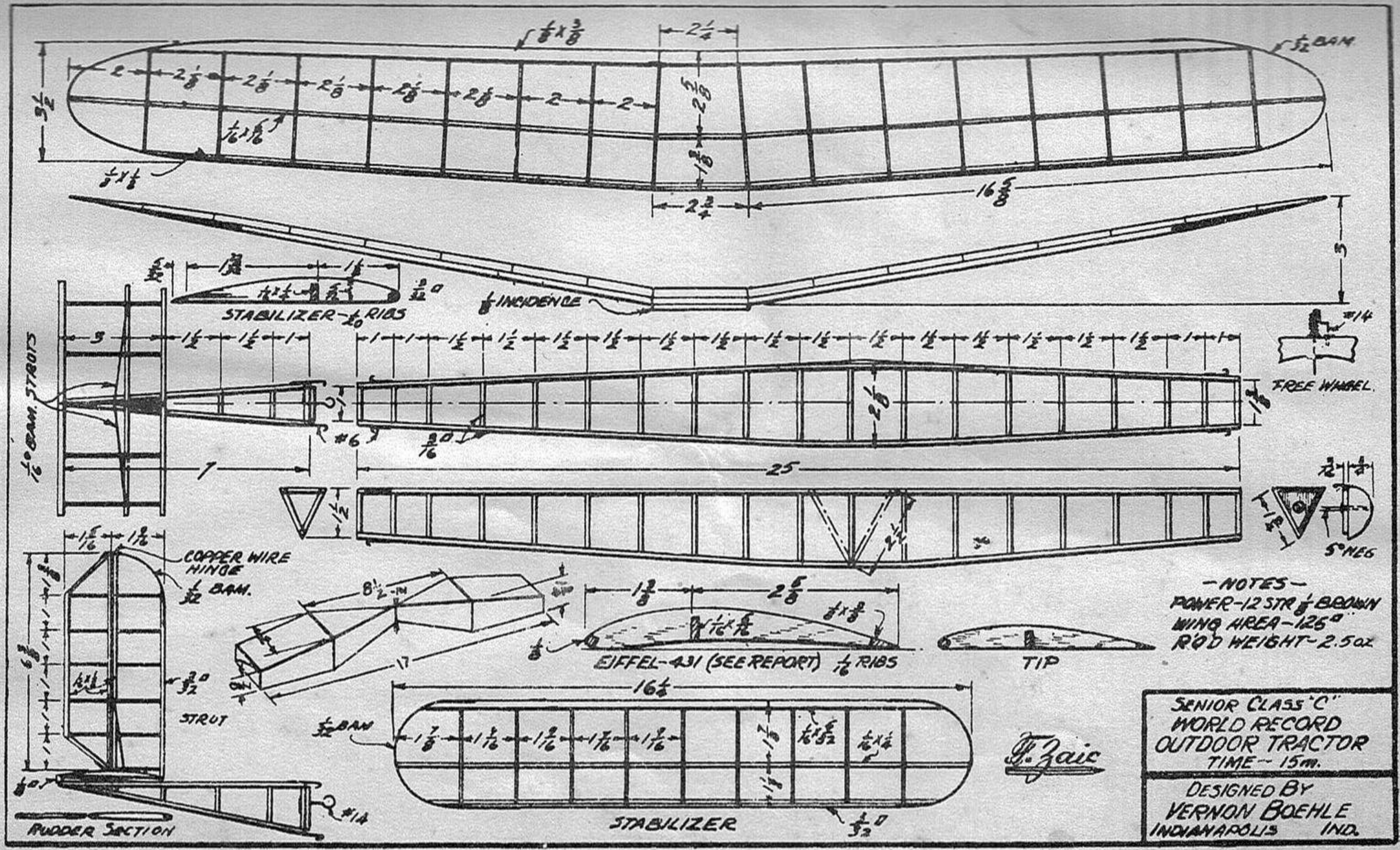
The same rules that were given for Cabin Fuselage are applicable to single stick tractor. The motor sick construction is the same as in single pusher, except that tail boom is added.

OUTDOOR WINGS

Tapered wings, elevators and stabilizers having aspect ratios of 9 to 11 are best. The taper should be in ratio of 1 to 1/2, that is, tip chord should be 1/2 of that of the center. High aspect ratio wing and elevator, not neccessarily tapered, should be used on twin pusher, to get most of lifting surface away from the frame eddies. Sweptback wing may be used on tractor with symmetrical tail to keep the C.G. forward, and, also, to decrease the dihedral and help stability with an upturned trailing edge. Never use more than 30° of total sweptback. A total dihedral of two inches for every foot of span is sufficient. Dihedral may be decreased if the Directional Center (D.C.) is high.

WING CONSTRUCTION

Avoid a multi-small-spar design, husky leading and trailing edges with just one center spar is much better. The multi small-spar wings might be brittle and seemingly strong, but any sudden strain will snap them, while a single spar wing will just bend. See the writer's ships for single center spar type of construction. The future designers will undoubtedly use Jim Cahill's construction except that 1/32 balsa sheet is recommended instead of 1/64. Wing tips should be of 1/16 round bamboo, and should extend for at least two panels along the edges.



STABILIZER - 1/20 RIBS
1/8 INCIDENCE
FREE WHEEL
1/16 BAM. STRUTS
COPPER WIRE HINGE
1/32 BAM.
STRUT
RUDDER SECTION
EIFFEL-431 (SEE REPORT) 1/16 RIBS
TIP
STABILIZER
- NOTES -
POWER - 12 STR 1/8 BROWN
WING AREA - 125 □"
ROD WEIGHT - 2.5 oz
SENIOR CLASS "C"
WORLD RECORD
OUTDOOR TRACTOR
TIME - 15m.
DESIGNED BY
VERNON BOEHLE
INDIANAPOLIS IND.
F. Zaic

The ribs should be of plus 1/32 stock, spaced about 1 1/2" or less to keep the airfoil outline between the ribs. Lightening holes are not essential as they weaken the ribs too much, and since advent of the weight rules cutting weight on vital parts is not neccessary. Little notches in the spars into which the ends of ribs are cemented strengthen and line up the wing well. Have the center spar equally spaced between upper and lower surfaces, to prevent the ribs from contracting at the point of attachment. The center spar should be placed about 40% of the chord from the leading edge.

COVERING WINGS

If paper is used, be sure to use many ribs to keep the airfoil section well. The grain of the paper should run from the leading edge to the trailing edge as paper shrinks most along the grain. Use dope to cement paper to the wood, and cement the paper to every rib. Shrink first with water. If a color is desired, mix aniline dye with water. Do not use colored dope. A coat of nitrate dope will waterproof and shrink the covering for average weather conditions. If model is expected to be flown in rough weather more coats of nitrate dope should be applied, but be sure that the construction is strong enough to take care of extra shrinkage. Decorate with enamels.

Balsa covered wings require fewer ribs, and the spars may also be smaller than those used in paper covered wings. The grain should run from tip to tip. Sheets of minus 1/32" wood are best. Two inch stock may be used by cementing the edges together.

A combination of the above two methods is best for practical purposes. Cover the center panels with balsa and the tips with paper. This improves stability by keeping the weight near the center, and the wing can also be handled better. It is a good idea to use sheet balsa whereever much handling is done. (See writer's Twin Pusher and Cabin Fuselage.)

AIRFOILS

In selecting your airfoils pick those that have a high C_l, a low C_d and a high L/D, at low incidences. (See airfoil reports.) The Clark Y, R.A.F.-32 and Eiffel 400 come under this, but the M6 does not; it has low drag and a high L/D, but the low C_l spoils it. You have to fly the M-6 at 6° incidence, to get the same lift that the R.A.F.-32 has at zero incidence.

It seems that airfoils that are used for gliders and soarers are suitable for model work, as long as they are not too thick. About 14% of the chord is the maximum that should be used. The under camber and the downward droop of the trailing edge are the characteristics of this type. The only objection to their use is that they have a large Center of Pressure (C.P.) movement. However, this can be corrected by having a high aspect ratio, surfaces, high wing, or a larger stabilizer.

The under camber determines at what angle the airfoil ceases to lift--the deeper the camber, the lower the angle. This type of airfoil usually has the best L/D at minus 2°, the ideal gliding angle. However, too much camber increases the resistance. Be reasonable; about 3% of the chord at the most.

Keep in mind that the best gliding angle is at the highest L/D. Soarers glide at this point. It simply means that at this point the least possible amount of weight is used to overcome the drag.

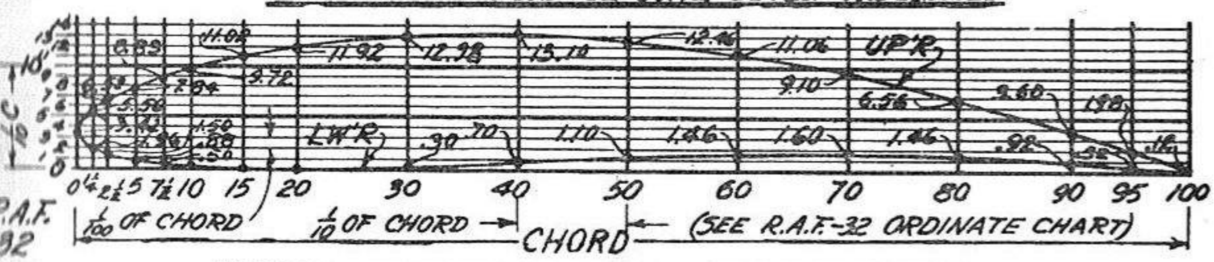
If there is enough lift, and the ship has little resistance, at the highest L/D, we can say that the gliding angle is the same as the L/D. That is, if the L/D is 20, then the glide is 20 to 1.

Consult airfoil report books before using your own section. You can be sure to find something like the one you have, and so you will be able to see just what characteristics your section has. However, it is a better policy to pick an airfoil from the book than to use your own. Besides knowing the characteristics, you can always duplicate the section by using the ordinates; then, too, taper wing ribs can be easily plotted.

USING THE RIGHT AIRFOIL

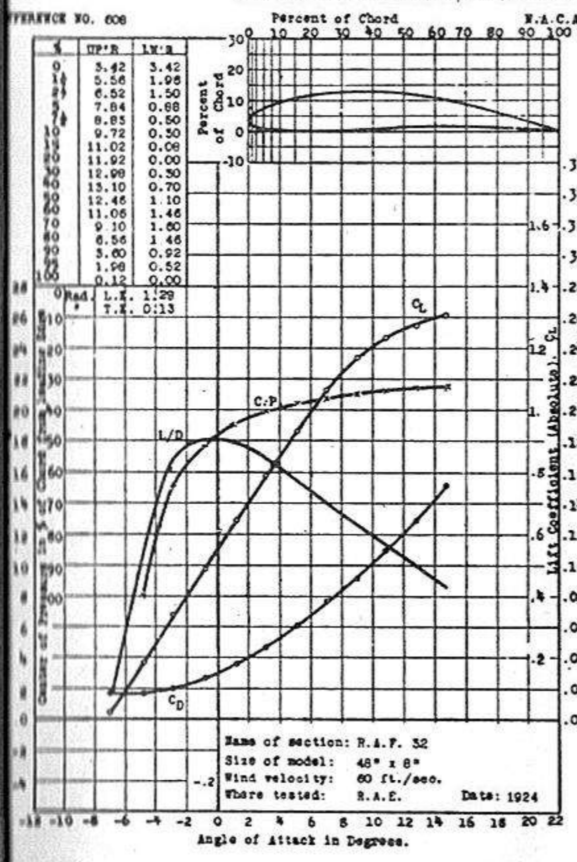
If a high wing is used on a tractor with a flat or symmetrical tail, a glider section can be used. If a lifting tail is used, use a stable section of the M-type. The loss of lift is compensated by the use of lifting tail. Never use under camber on a lifting tail: M-sections are preferable as we do not want the tail to lift in the glide. Set the M-section at a higher angle of attack or incidence. On a pusher, we may use under camber on the elevator and the wing, but that of the elevator should be deeper so that it has more lift than the wing at negative attack. Use M-sections on the tailplane, as they do not lift well at negative angle of attack.

PLOTTING AN AIRFOIL FROM GIVEN ORDINATES

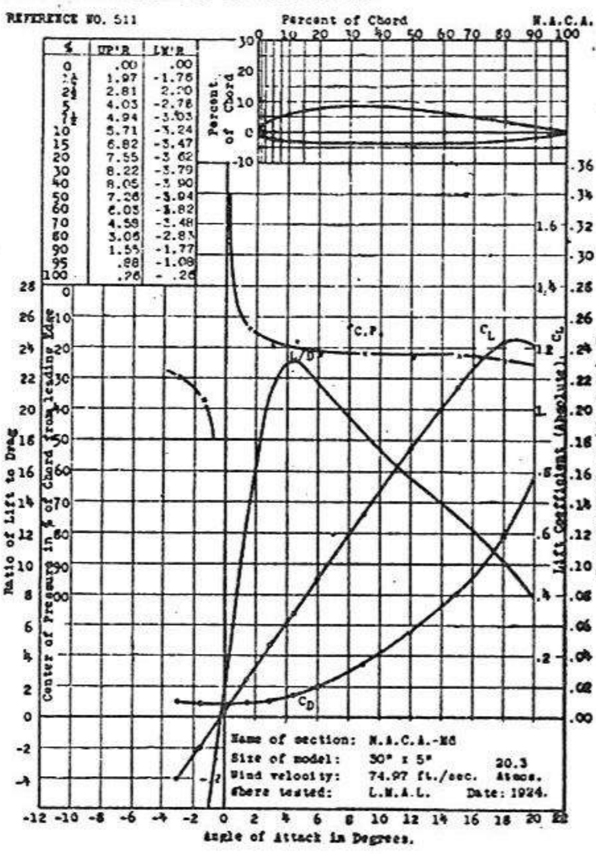


NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

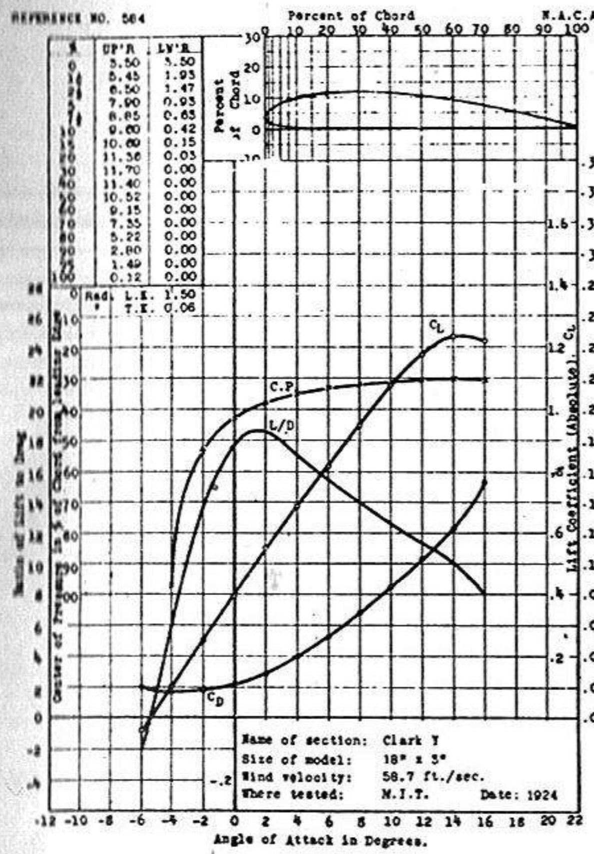
AERODYNAMIC CHARACTERISTICS OF AIRFOILS

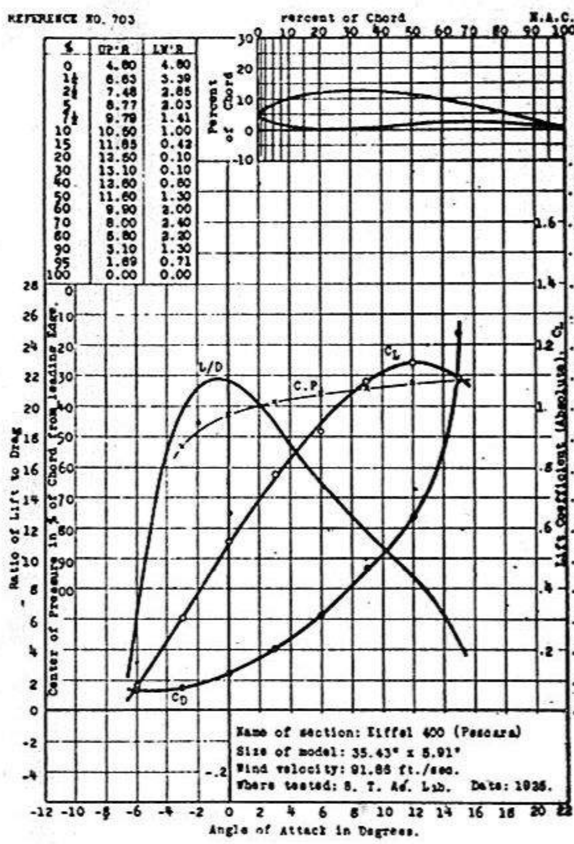


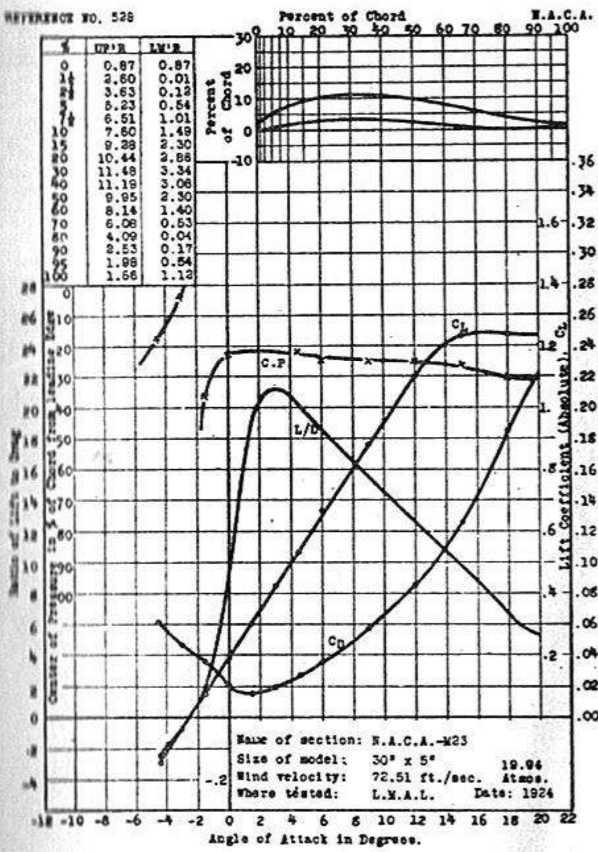
%	UP'R	LW'R
0	3.42	3.42
1¼	5.56	1.96
2½	6.52	1.50
5	7.84	0.88
7½	8.85	0.50
10	9.72	0.30
15	11.02	0.08
20	11.92	0.00
30	12.98	0.30
40	13.10	0.70
50	12.46	1.10
60	11.06	1.46
70	9.10	1.60
80	6.56	1.46
90	3.60	0.92
95	1.98	0.52
100	0.12	0.00

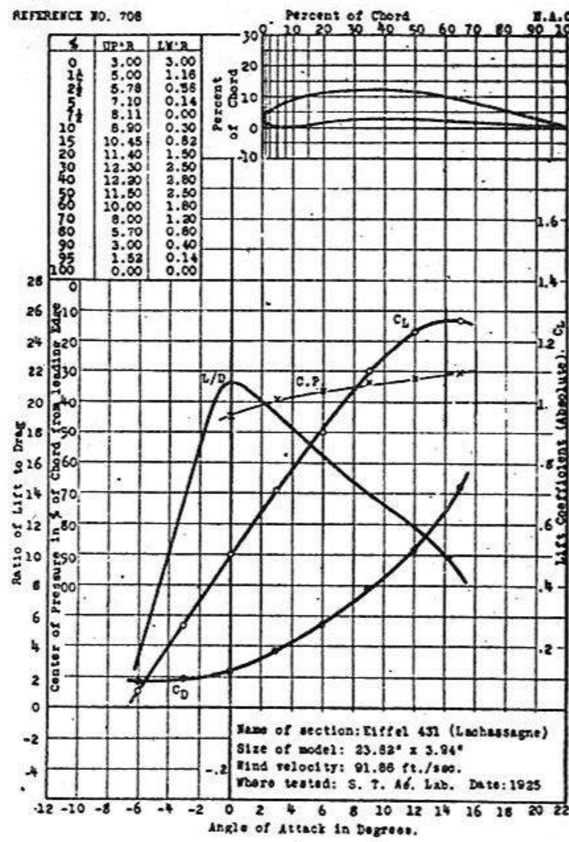


%	UP'R	LW'R
0	.00	.00
1¼	1.97	-1.76
2½	2.81	2.[illegible]0
5	4.03	-2.78
7½	4.94	-3.03
10	5.71	-3.24
15	6.82	-3.47
20	7.55	-3.62
30	8.22	-3.79
40	8.05	-3.90
50	7.26	-3.94
60	6.03	-3.82
70	4.58	-3.48
80	3.05	-2.83
90	1.55	-1.77
95	.88	-1.08
100	.76	- .26









ADDITIONAL AIRFOIL SECTIONS may be found in N.A.C.A. Reports Nos. 93, 124, 182, 244, ,286, 315, and 460. These reports may be seen in your library or be purchased on application to the ---

AIR CENTRE LIBRARY, AT 14 MARTIN PLACE, SYDNEY.

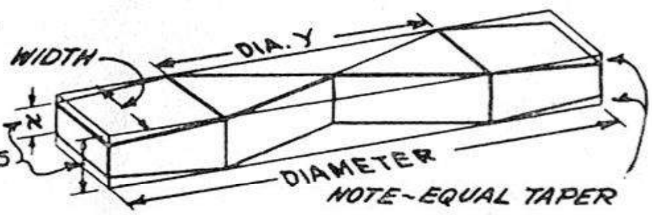
OUTDOOR PROPELLERS

The writer believes that best all around props for outdoor work are carved from blanks having width of 2 inches, and thickness of 1 1/2 inches, and the desired diameter. The pitch is 1 1/2 times the diameter at the tip and about 90% of the pitch where side taper joins plan taper. (See diagram.) Use the pitch formula (A) by substituting the known factors with numerals, as shown in Examples "B" and "C". This method may also be used for true pitch props when blank has to be tapered to secure the desired pitch; just have full pitch, instead of 90%. in "C" equation.

A. $$\frac{3.1416 \times DIAM. \times THICKNESS}{WIDTH} = PITCH$$

B. EX. $$\frac{3.1416 \times 12 \times X}{2} = 18''P \ (1\tfrac{1}{2} \text{ dia}) \qquad X = .95$$

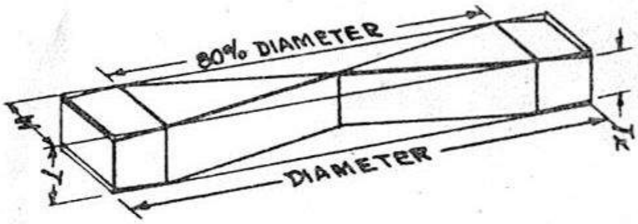
C. $$\frac{3.1416 \times Y \times 15}{2} = 16.2''P \ (90\% P.) \qquad Y = 7''$$



If you wish to use other blank sizes, the writer recommends Mr. Keck's method of finding the most efficient pitch-diameter ratio. Mr. Keck found, by tests, that greatest efficiency in foot-ounces of thrust was secured from props having a blade angle at 40% of the blade length from the hub, corresponding to a pitch 20% less than the pitch at the tip. (Information on props, and model designing in general, may be found in "The Model Flyer's Guide", by Charles E. Keck. It can be obtained by sending 10¢ to--Pioneer Model Airplane Supply Co.--Champaign, Illinois.)

$$\frac{3.1416 \times DIAM. \times THICK. X}{WIDTH} = PITCH$$

$$\frac{3.1416 \times 80\% DIAM \times THICK.}{WIDTH} = 80\% P$$



PROPELLER OUTLINE

The outline of a prop should be such, that the point that is most likely to hit the ground or obstructions, should be connected to the hub by direct grain.

PROP OUTLINE

PROP NOTES

THE ROTATION of props on twin pusher should be convenient for winding. FREE WHEELING: See plans for various free wheeling designs. Make all and decide for yourself which is best. Covering the cupped side of the prop with paper or silk strengthens the blade.

CENTER OF GRAVITY

The Center of Gravity (C.G.) is a very important factor to consider in relation to the position and size of the various surfaces of a model. It is found by the method shown on the drawing. Page 15.

ESTIMATING C.G. ON NEW DESIGNS

The approximate C.G. is almost always on the center of the rubber motor. It moves back if a heavy tail or a straight wing (no sweepback) is used, and forward, if the landing gear is heavy. Sweepback does not change the C.G. The C.G. moves forward on a lifting tail designs, as the wing is in the front of it. The amount of movement depends on the weight of the wing, and the distance from C.G. required by certain size of stabilizer. See your Physics book for more information.

C.G. AND THE STABILITY

A low C.G. does not have all the stability features attributed to it. When a strong gust hits a model having very low C.G., obtained by heavy wheels or freaky construction, etc., the low weight has a tendency to swing the model into a stall, and if it recovers, it is usually because of the Aerodynamic stability of the plane. The same applies to the dihedral motion. The fact is that models having a low C.G. take much longer to recover as the weight has a tendency to keep on swinging back and forth, until the motion is finally dampened by Aerodynamic stability.

C.G. AND CENTER OF THRUST

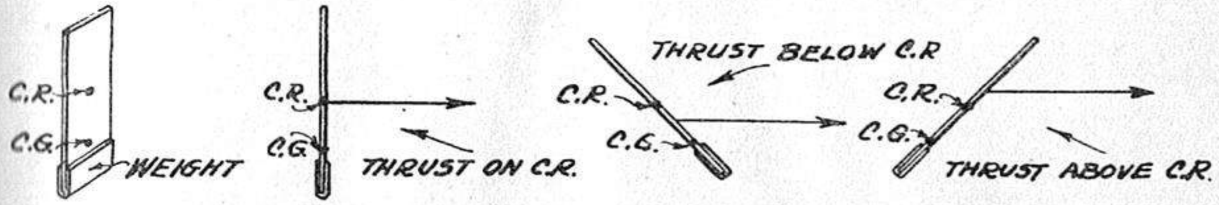
The couple produced by Center of Thrust (C.T.) and C.G. should be disregarded as the model does not turn longitudinaly, up and down on the C.G., althought most of the aeronautical text books state that fact. The writer believes that the model turns on a point smewhere between C.G. and Center of Resistance.

CENTER OF RESISTANCE

The Center of Resistance (C.R.) is the point where the frontal resistance is balanced. It varies with different angles of attack.. On a straight flight it is usually above C.G., if a high wing is used

PROVING THAT C.R. IS THE LONGITUDINAL TURNING POINT

The following test was made to prove writer's statement that C.R is the aerodynamic turning point: A rectangular balsa sheet was weighted on one end until it was just submerged unde water in a tank. The C.G. and the C.R. were marked on the sheet and a string attached to various points, as shown on the drawing, and then the sheet was pulled horizontally through the water. It was also pulled vertically with the same results.



This test proves that turning point depends upon the C.R., but as water has higher viscosity than air, we can compromise by stating that the turning point is between C.R. and C.G., depending on the intensity of each factor.

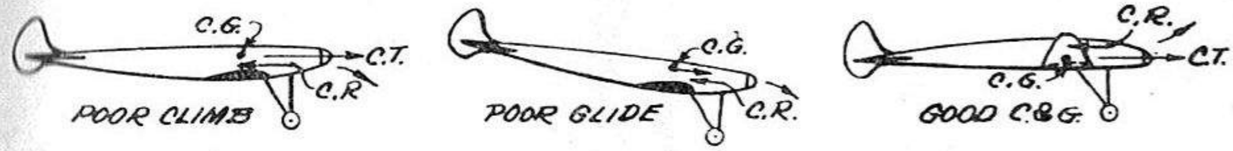
THE POSITION OF C.T. AND C.G. IN RESPECT TO C.R.

From the experiment we can see that C.T. should depend on C.R. and not on C.G. The best position for C.T. is under C.R., as that wil tend to climb the model until the C.R. moves below the C.T. because of the drag introduced by the stabilizer. Then, with the help of lift on the stabilizer and the lower C.R., the model straightens out, until just the right point is reached where the forces are balanced. If C.R. is below C.T. the model dives. A low wing ship is a good example of what happens with this arrangement.

The C.G. should also be under the C.R. as this will make the model assume the best gliding angle. The C.G. over the C.R. makes the model dive. Take as an example a low wing ship.

LOW WING AND C.R.

We can see that a low wing design should have low rubber motor to bring the C.T. and the C.G. below the C.R. A fairly large dihedral will bring the C.R. high. Do not use heavy wheels to bring C.G. down, because of the reasons stated before.



DIRECTIONAL CENTER

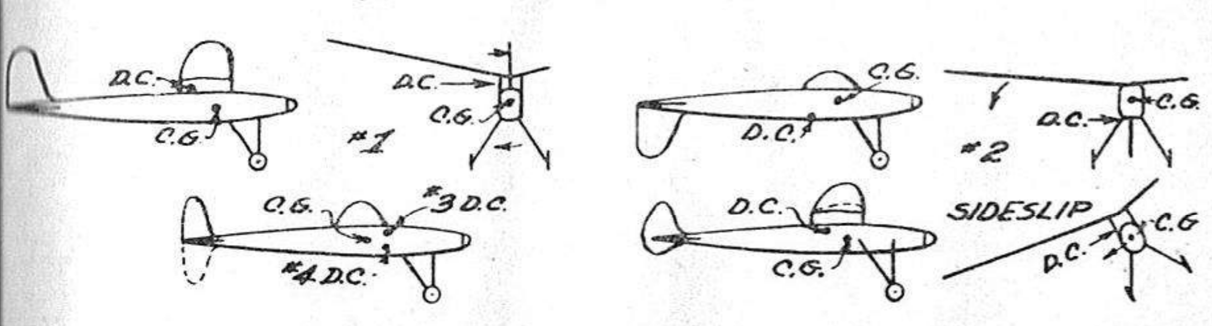
The Directional Center (D.C.) is the center of all side or profile areas. It is the point on which the model tends to turn. Because of the C.G., however, it has to compromise. The rudder or the fin usually determine the D.C. on tractors, and the dihedral of the elevator on pushers, and as the D.C. has a great effect on stability we will show you how to calculate the correct rudder areas and the dihedral of pusher elevator.

PRINCIPLE OF DIRECTIONAL CENTER

The Directional Center works on the weather vane principle. That is, the large areas swing away from the wind and bring the pointer to bear in the wind's direction. The same principle applies to models. When a side gust hits the model the side that offers greatest resistance swings around C.G., and if there is no balancing area in the opposite side, it tends to keep on swinging, with a spin in which the low area side eventually rotates around the larger area as the result. A single pusher with the D.C. way behind the C.G. is a good example of what not to do.

EFFECTS OF D.C. ON STABILITY

There are four possible positions of the D.C. on a model, as shown on the drawing.



Position #1 will give the model a tendency to swing into a side gust with the inside wing high. This is bad for low power ships, but all right for higher power jobs, as they ride the gust. If the D.C. is still higher than shown, the model will fly cross wind, or the familiar "crabbing".

Position #2 will also tend to fly the model into the wind, but with inside wing low. Consequently the model will automatically bank into the gust. However, this feature is bad, in that it makes the model fly always into the wind, and the model must be overcontrolled to have it circle. The D.C. way back will also have this tendency.

Positions #3 and #4 are bad. Such location only could cause "Dutch Roll", that is, the tail swings first to the right, then to the left, each swing becoming more violent until the flight path changes into a spiral dive. Cure - more rudder.

The best position for D.C. is about an inch behind C.G. and just above it. This makes the model controllable, and inherently stable by having area above C.G. the model tends to righten itself in a side-slip.

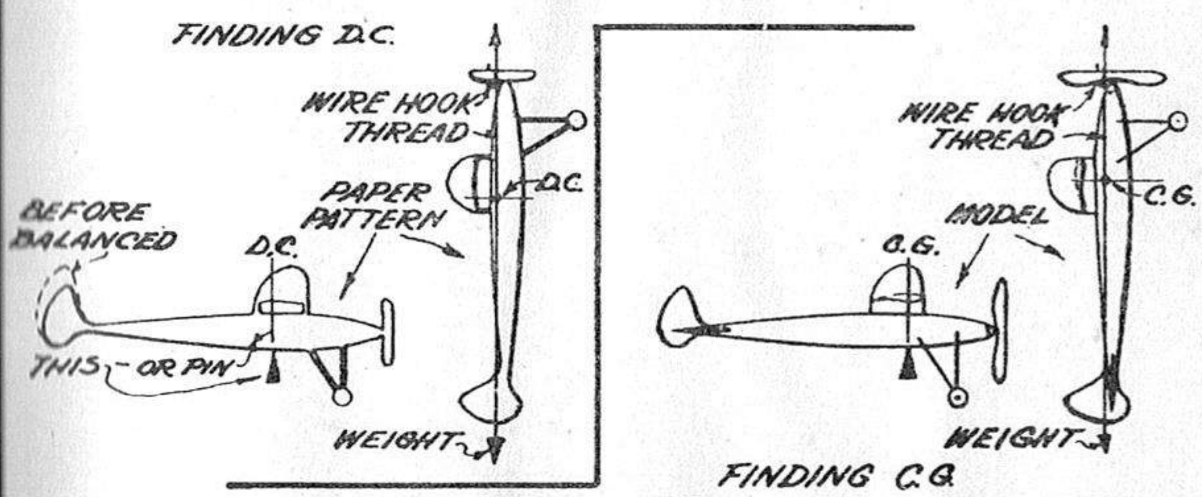
It would be worth your while to try all the positions to see just how they work. Test on gusty days, as unstable models sometimes fly well in calm weather.

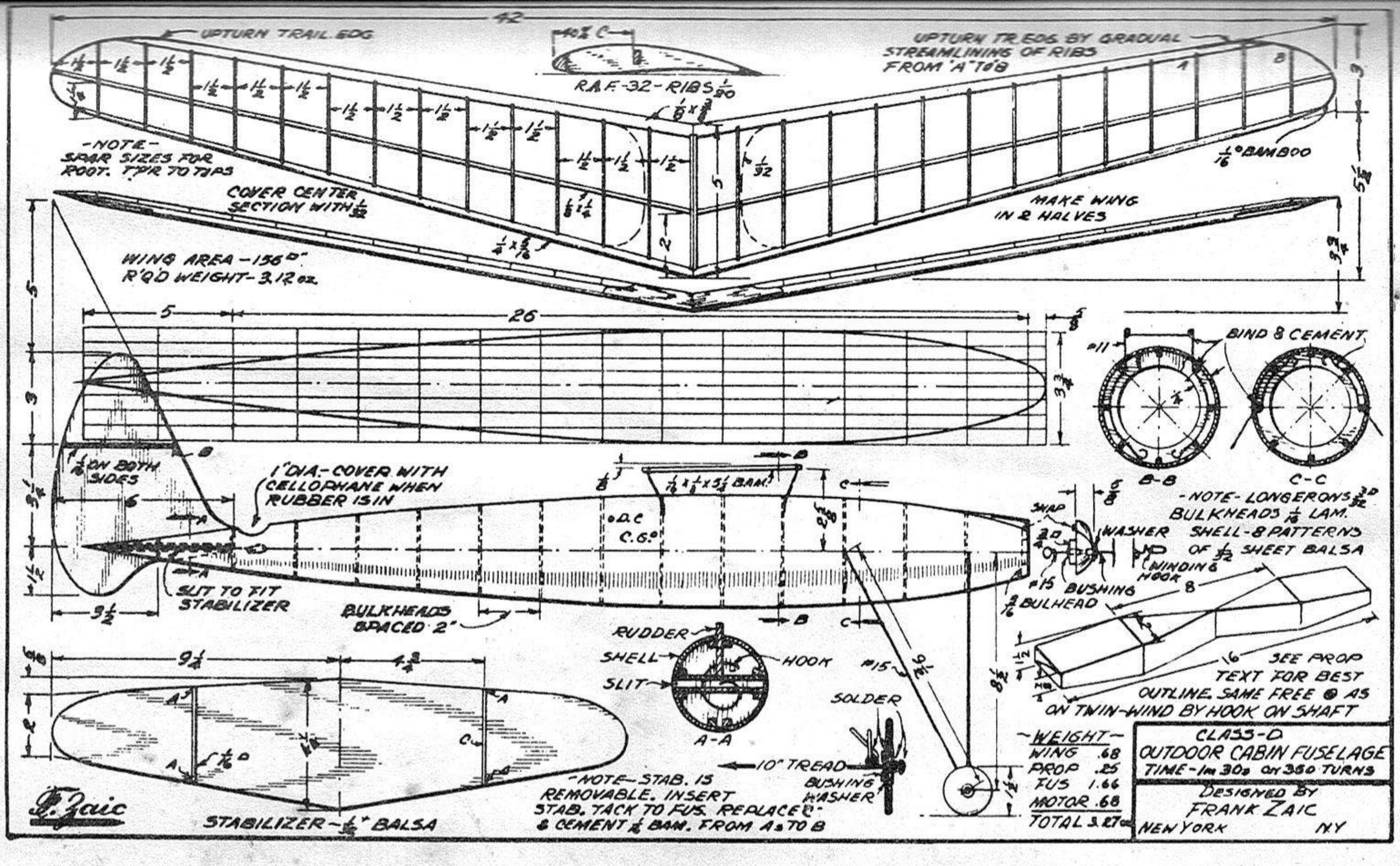
FINDING D.C.

To find the D.C. of a model or a design, the side areas can be computed and the center determined, but it is much easier to cut a paper pattern to scale of the side view of the model, and then by balancing this by method shown, finding the center of gravity of the paper. This center of gravity of the pattern is the D.C. on the model. When finding the D.C. from pattern it is advisable to have a larger rudder which can be trimmed to the proper area. Use only half of the prop for side area.

FINDING D.C. ON PUSHERS

The D.C. on the pusher is found in the same manner as in tractors and it is just as important to have it just behind the C.G. In pushers, the elevator can serve as fin by giving it enough dihedral to bring the D.C. behind C.G. A fin can be used if the dihedral becomes excessive. When testing pushers for their D.C., be sure that the position of the surfaces has been determined before. That is why it is advisable to make the elevator last.





UPTURN TRAIL. EDG
UPTURN TR. EDG. BY GRADUAL STREAMLINING OF RIBS FROM 'A' TO 'B'
R.A.F.-32-RIBS
-NOTE- SPAR SIZES FOR ROOT. TPR TO TIPS
COVER CENTER SECTION WITH
BAMBOO
MAKE WING IN 2 HALVES
WING AREA-156□"
R'Q'D WEIGHT-3.12 oz
ON BOTH SIDES
1" DIA.-COVER WITH CELLOPHANE WHEN RUBBER IS IN
SLIT TO FIT STABILIZER
BULKHEADS SPACED 2"
BIND & CEMENT
B-B
C-C
-NOTE- LONGERONS
BULKHEADS LAM.
SHELL-8 PATTERNS OF SHEET BALSA
SHAP
WASHER
WINDING HOOK
BUSHING
BULHEAD
SEE PROP TEXT FOR BEST OUTLINE. SAME FREE AS ON TWIN-WIND BY HOOK ON SHAFT
RUDDER
SHELL
SLIT
HOOK
A-A
SOLDER
10" TREAD
BUSHING
WASHER
-NOTE-STAB. IS REMOVABLE. INSERT STAB. TACK TO FUS. REPLACE & CEMENT BAM. FROM A TO B
STABILIZER- BALSA
-WEIGHT-
WING .68
PROP .25
FUS 1.66
MOTOR .68
TOTAL 3.27 oz
CLASS-D
OUTDOOR CABIN FUSELAGE
TIME-1m 30s ON 350 TURNS
DESIGNED BY
FRANK ZAIC
NEW YORK NY
F. Zaic

SOLID BALSA GLIDERS

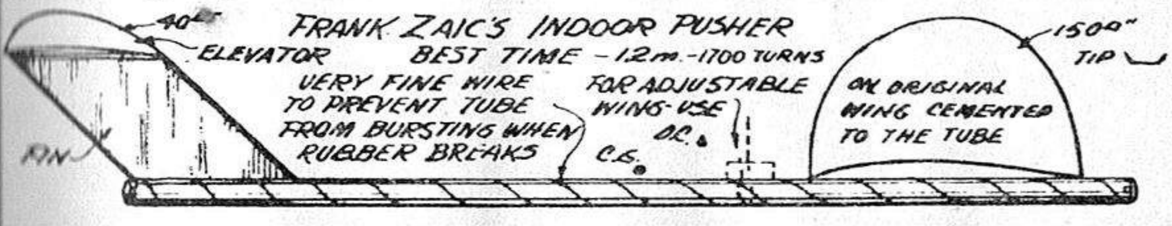
The original handlaunched Sweepback Glider, which is now gaining uch popularity throughout the country, was designed by the writer nd his brother, John, in the summer of 1930. Since then many im-rovements have been made on the design, especially by John Young and he New York Aeronuts, which raised the few seconds of before-1930 to he present high time. The main requisite for high performance glider re stability, a minimum resistance, and wings strong enough to with-tand the terrific strains of baseball-like launchings. The Sweep-ack glider meets all these requirements: The dihedral and the sweep-ack combination give the glider the neccessary stability and also he needed strength.

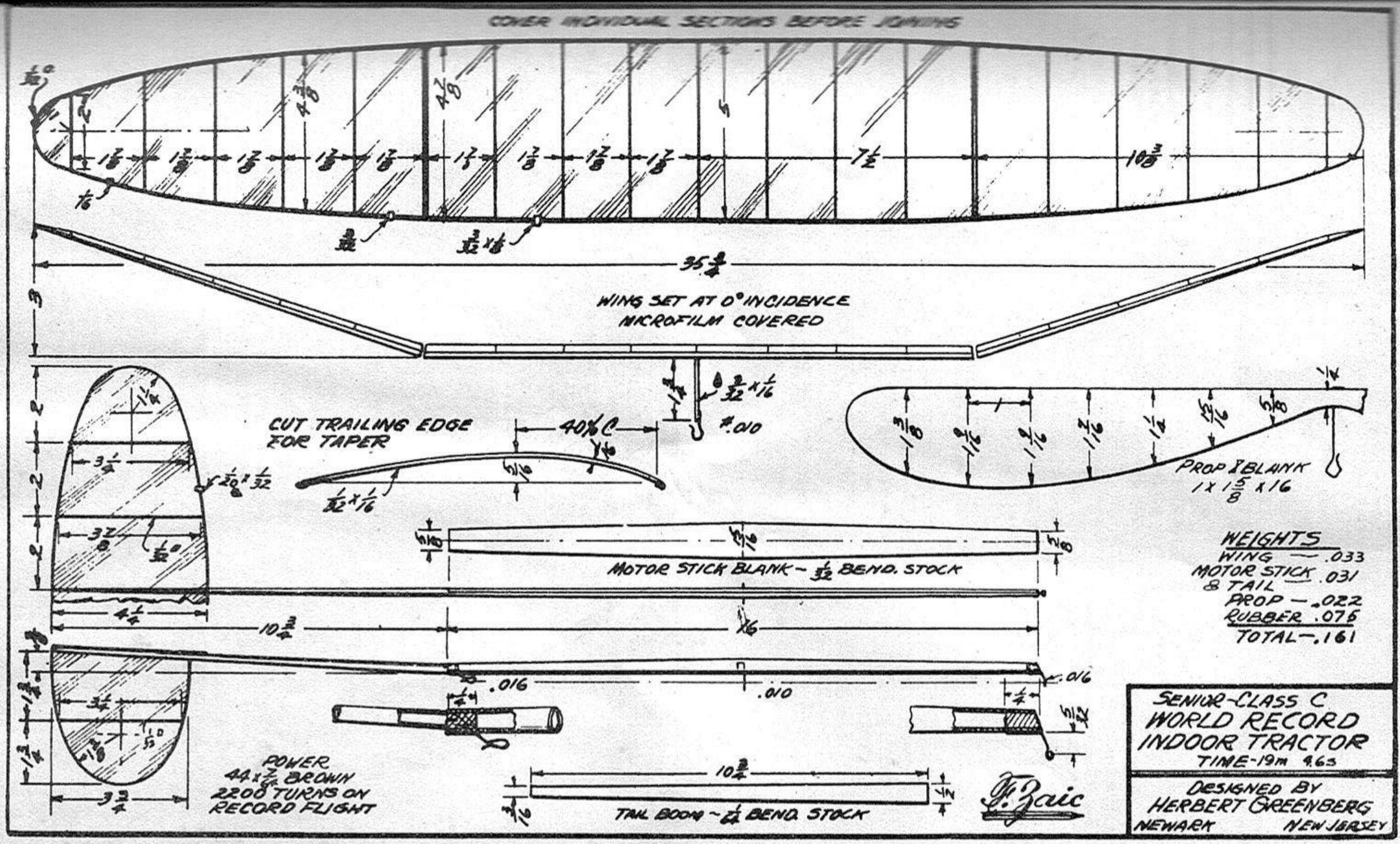
See the glider plans for the general outline and construction etails. Notice how sturdy and streamlined the essential parts are ade. Besides the profile drag, we must also take care of the skin riction. This is done by using 10 nought sandpaper for final sanding nd making the surfaces permanently smooth by applying to it several oats of lacquer, or banana oil, or microfilm solution, that will not arp the thin surfaces, with intermediate sandings of 10 nought andpaper.

The correct launching and setting is very important, especially ndoors, where there are no rising thermals. The glider should be ad-justed so that when it is thrown into a right turn, it straightens out nd glides into a left turn. This is done by giving the left wing a ashin, when looking from the front. This setting is for a right anded fellow, and vice versa for a left hand person. The most ele-entry throw is to hold the glider vertically, with the above setting nd launch it by swinging the arm in a arc, releasing the glider when he hand is begining to come towards the body. The glider should go nto a fairly tight right turn, gradually increasing the radius until t straightens out and goes into a left turn. The most successful ethod for record and contest launching was first developed by John oung of New York. He throws the glider into the air as thought it as a baseball, except that the glider is banked slightly for a right urn. The height he and his colleagues get is amazing! Over 70 feet ndoor! But they feel it for the next few days. Of course, the wings f the first few gliders collapse under this tremendous force, but we oon learned by experience which grade of wood is the best. And, do ot forget that good proverb, "Practice makes perfect."

INDOOR PUSHER

Up to date very little has been done to develop Indoor Pushers, ecause the original indoor models were tractors, and only a few ardy souls dared to build pushers. Their were fruitless, in most nstances, however, because in their pusher designs the motor stick sed to twist so as to help the torque, and also, the models spun t the slightest provocation. Misplacement of the Directional Center as the cause of the spin; it was too far back of the C.G. The riter has designed an Indoor Pusher, (see drawing), which eliminates ll these faults. By enclosing the rubber in a tube, the twist of he stick is negligible, and the fin area in the front brings the D.C. ust behind the C.G., where it should be. Of course, a larger dihe-ral on the elevator, instead of the fin, may serve to bring the D.C. o the right place.




COVER INDIVIDUAL SECTIONS BEFORE JOINING
WING SET AT 0° INCIDENCE
MICROFILM COVERED
CUT TRAILING EDGE
FOR TAPER
40% C
PROP I BLANK
1 x 1 5/8 x 16
MOTOR STICK BLANK ~ 1/32 BEND. STOCK
WEIGHTS
WING — .033
MOTOR STICK & TAIL .031
PROP — .022
RUBBER .076
TOTAL — .161
POWER
44 x 7/64 BROWN
2200 TURNS ON
RECORD FLIGHT
TAIL BOOM ~ 1/64 BEND. STOCK
SENIOR-CLASS C
WORLD RECORD
INDOOR TRACTOR
TIME-19m 4.6s
DESIGNED BY
HERBERT GREENBERG
NEWARK NEW JERSEY
F. Zaic

INDOOR ENDURANCE MODEL

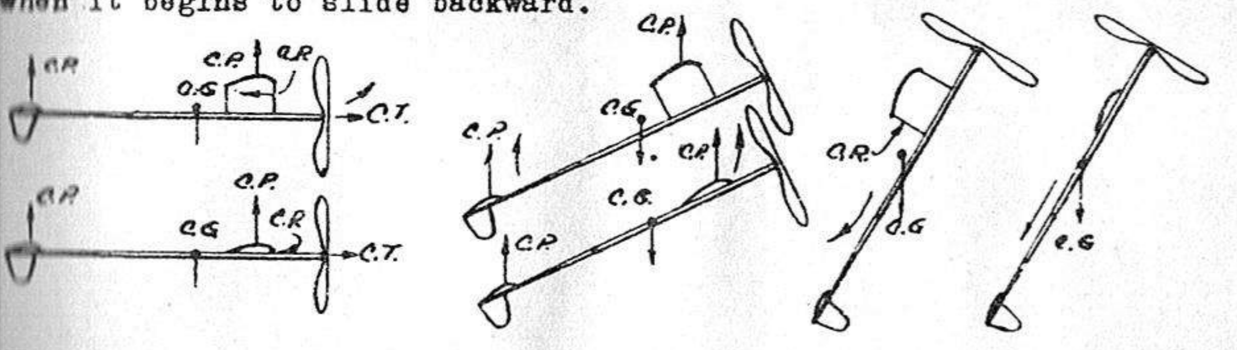
See the Indoor plans for the design and construction details. When making a model from plans, and the weights do not check, the reason probably is that a different grade of balsa was used. If you use 8 lbs. per cu,ft. balsa on a design which was originally built of 4 lbs. stock, your model will naturally weigth almost twice as much.

Indoor balsa should average between 3.5 lbs. to 5.5 lbs per cu. ft. It is preferable to use larger size of light balsa, instead of a small size of heavier wood which comes to the same weight. The larger size can be streamlined easier and is stronger, per weight, because of the larger cross section. Oval-shaped motor sticks, hollow booms, and all tubing, should be made of balsa that does not angle when passed between the thumb and the index finger. Spar stock should be slightly tougher. For cut ribs, use speckled balsa, as it does not straighten out when cut to the rib outline.

STABILITY OF INDOOR TRACTOR

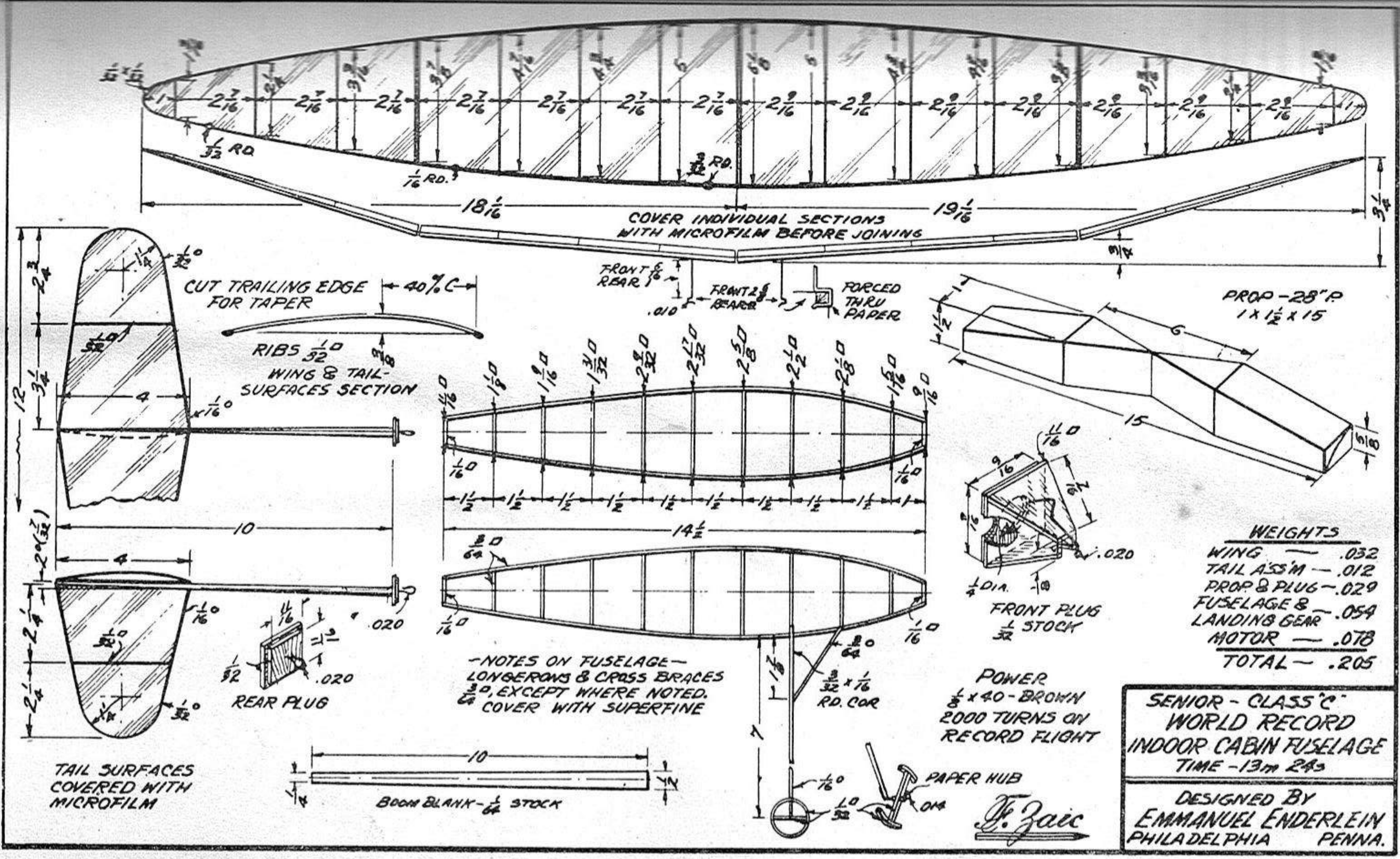
The present trend in Indoor designing is to have a high wing and a cambered stabilizer on a boom. This combination combines stability and efficiency. The cambered stabilizer contributes lift, and the high wing makes the model stable. The formula for calculating the stabilizer area is the same as that of lifting tail Outdoor Tractor.

Space does not permit us to discuss the merits of high and low wings. All we can say is that we have tried both systems, and the high wing has proved to be the best from an efficiency and stability standpoint. (See the drawing for comparison of the two arrangements.) It is much easier to adjust a high wing model, as the adjustments can be rougher than on a low wing model, because the Center of Pressure, or Lift, moment arm becomes smaller when the wing is at a high angle of attack or near a stall, and giving the tail a greater lever arm, thus straightening out the ship. In a stall to standstill, the Center of Resistance (C.R.) above the C.G. straightens the model when it begins to slide backward.



INDOOR PROP

The indoor prop outline, as shown in the Indoor plans, is for a high ceiling flying. For a low ceiling use the outline developed by Mr. Walen of Springfield, Mass. Mr. Walen states that with this outline he is able to get 3 to 4 minutes before the model reaches a 60 ft. ceiling and yet comes down dead stick. The principle involved is that the blades increase their pitch when the motor is fully wound. (Some of the old timers will recognize this prop as a modification of that of Joseph Culver of California at the 1929 National Contest.)

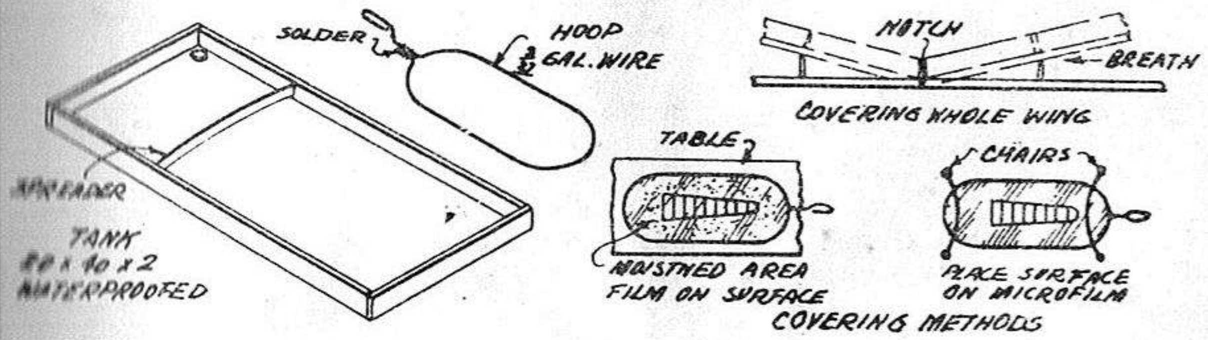


COVER INDIVIDUAL SECTIONS WITH MICROFILM BEFORE JOINING
CUT TRAILING EDGE FOR TAPER
40% C
RIBS 1/32 □
WING & TAIL-SURFACES SECTION
FORCED THRU PAPER
PROP - 28" P.
1 x 1½ x 15
WEIGHTS
WING — .032
TAIL ASS'M — .012
PROP & PLUG — .029
FUSELAGE & LANDING GEAR — .054
MOTOR — .078
TOTAL — .205
FRONT PLUG 1/32 STOCK
REAR PLUG
-NOTES ON FUSELAGE-
LONGERONS & CROSS BRACES 3/64 □, EXCEPT WHERE NOTED.
COVER WITH SUPERFINE
POWER
1/8 x 40 - BROWN
2000 TURNS ON RECORD FLIGHT
PAPER HUB
TAIL SURFACES COVERED WITH MICROFILM
BOOM BLANK - 1/64 STOCK
SENIOR - CLASS "C"
WORLD RECORD
INDOOR CABIN FUSELAGE
TIME - 13m 24s
DESIGNED BY
EMMANUEL ENDERLEIN
PHILADELPHIA PENNA.
F. Zaic

MICROFILM

Almost any lacquer or dope will serve as microfilm solution if proper amount of flexizer is added to make the film flexible. Castor Oil is the most common, but it should be used in just the right amount as it is liable to make the film tacky if used excessively. Those wishing to experiment in this field should read up on lacquer literature in their library.

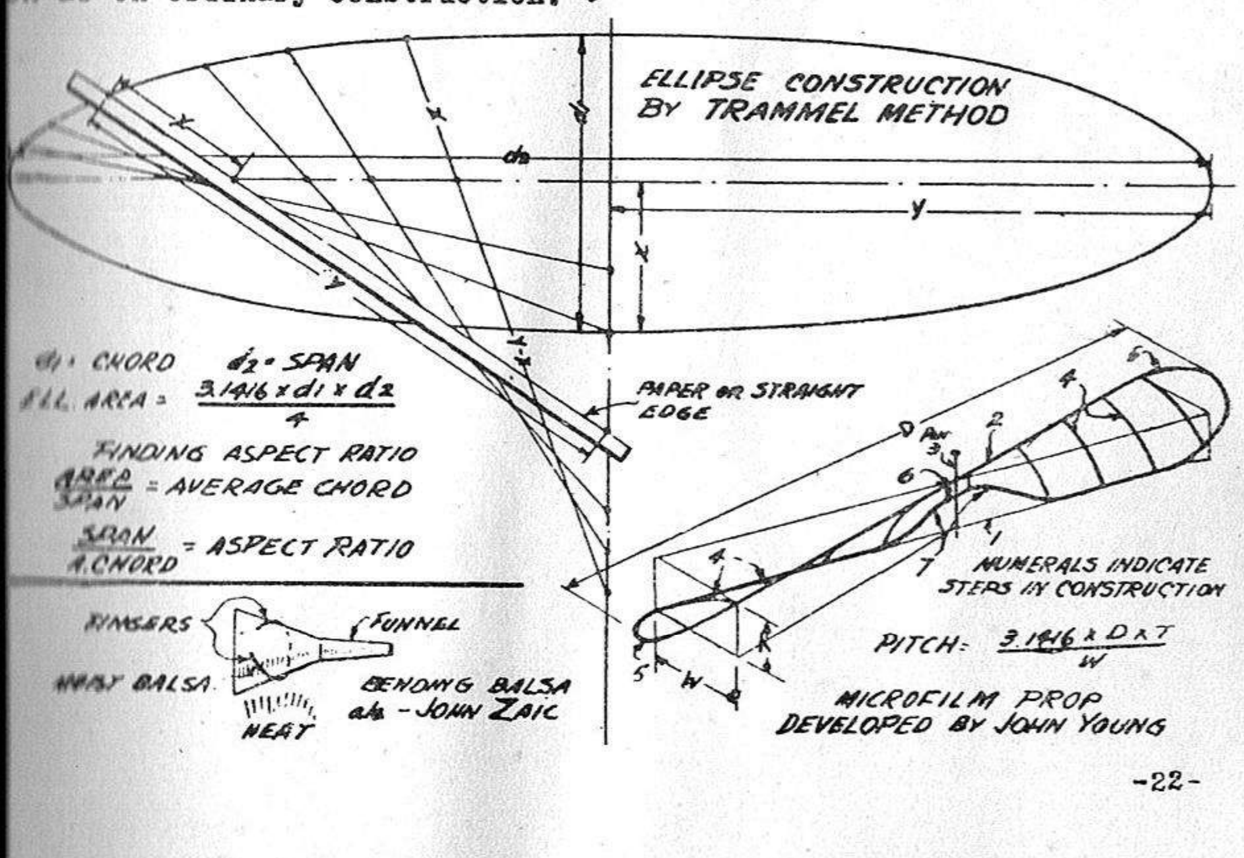
Use Red and Greenish colors for tractor wings, and Gold, Silver and Violet for tail surfaces and R.O.G.'s. These colors are used by the N.Y. Aeronuts, who have been working on film ever since it was introduced, and, naturally, have a good solution. If you are just beginning to use microfilm it is advisable to use thicker sheets, but never go out of the color range. Use saliva for adhesive, and hot wire or acetone for trimming. Wings can be covered in one piece by notching the spars for dihedral, and then covering with film. Make dihedral, and blow underneath the wing to crease the stack film. You may find more hints just by experimenting. You know, a day of experimenting on your own will teach you more than you could learn from the most complete treatise ever compiled.

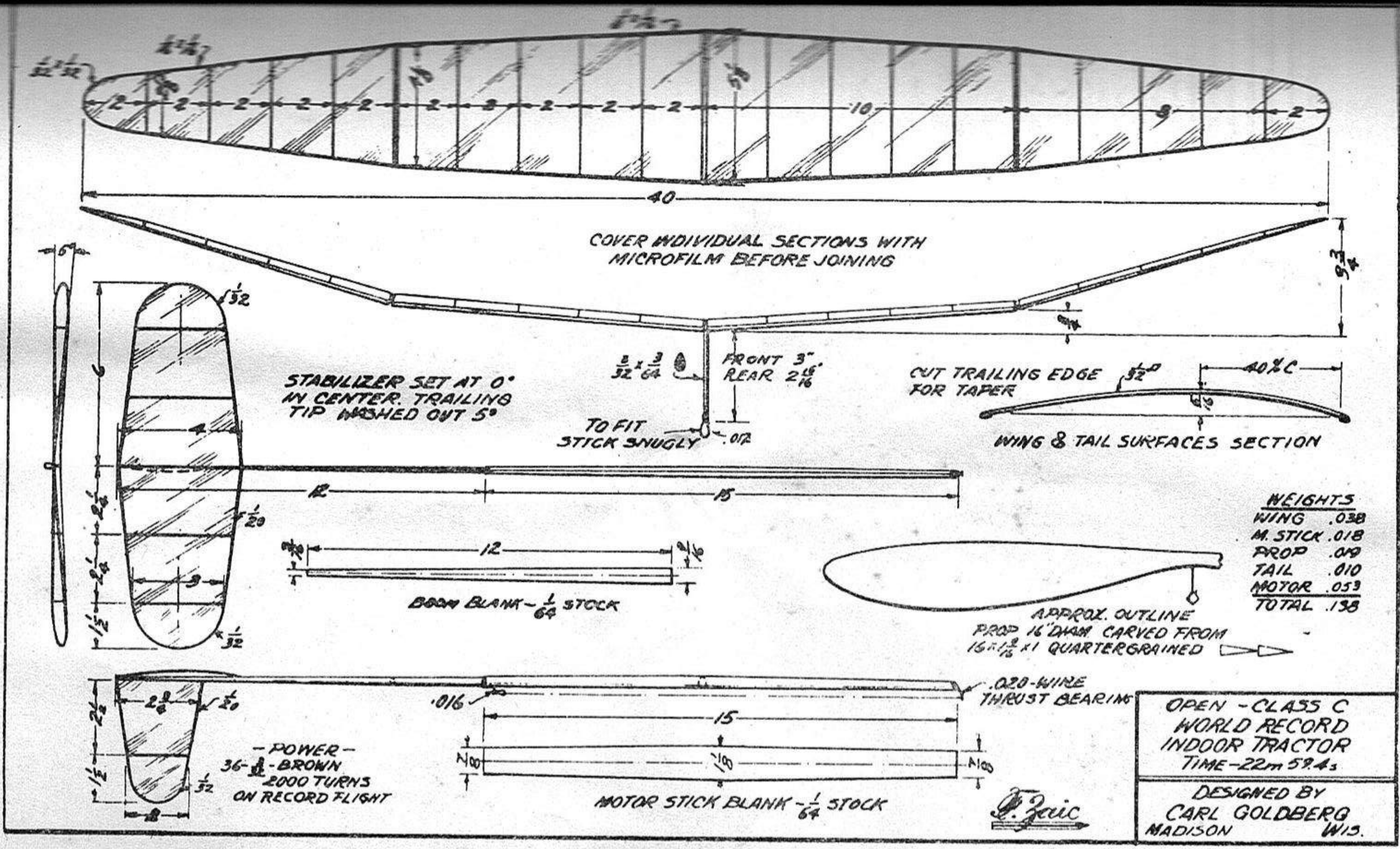


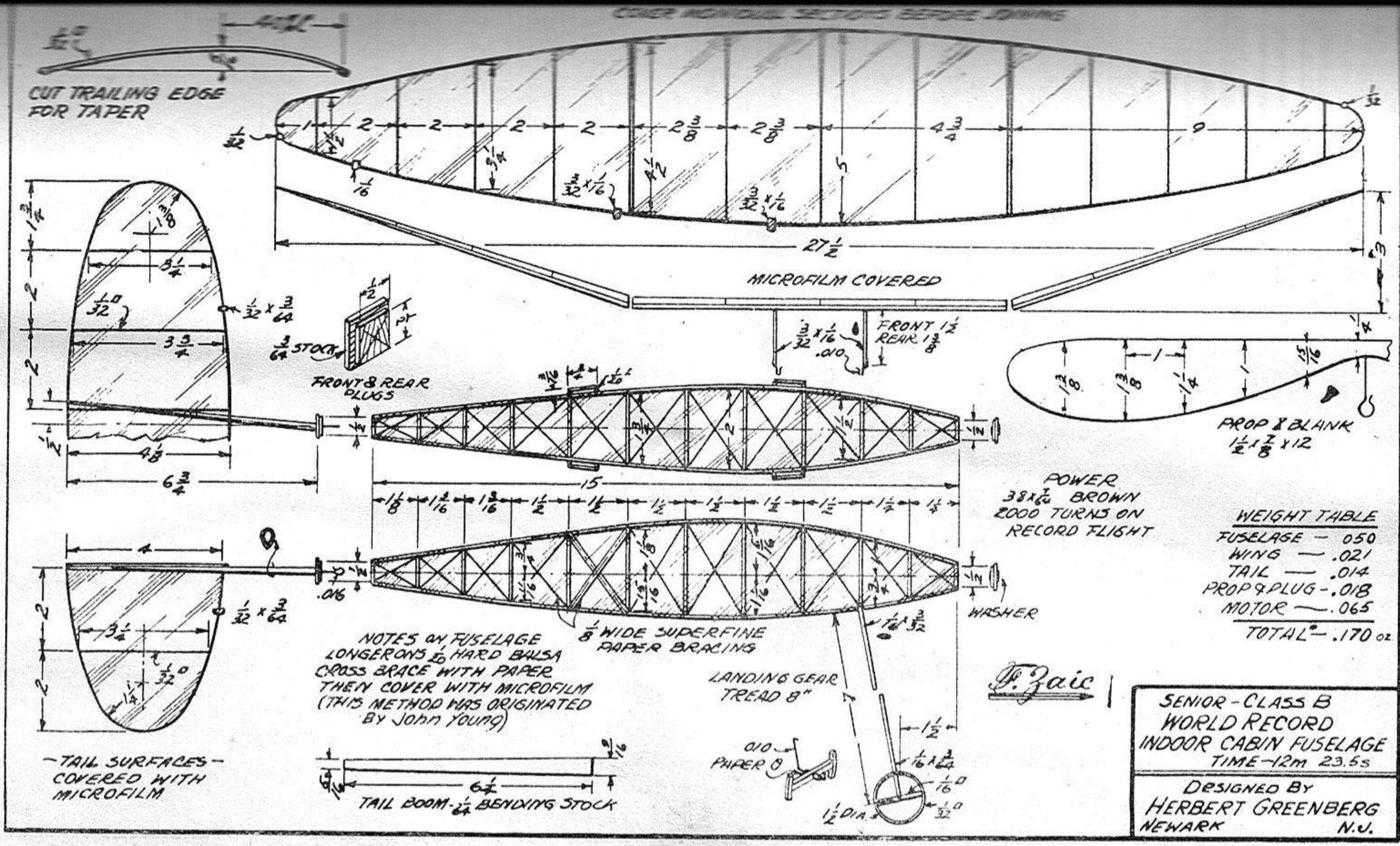
METHOD FOR MAKING ELLIPTICAL WINGS

Developed by Lawrence Smithline

Draw the ellipse. Superimpose spars on the drawing. Hold spars in place with pins. Place and cement ribs. Moisten the spars to keep shape. When dry, remove from the board and add tips, and carry on as on ordinary construction.




COVER INDIVIDUAL SECTIONS WITH MICROFILM BEFORE JOINING
STABILIZER SET AT 0° IN CENTER. TRAILING TIP WASHED OUT 5°
FRONT 3". REAR 2 15/16
TO FIT STICK SNUGLY
CUT TRAILING EDGE FOR TAPER
40% C
WING & TAIL SURFACES SECTION
BOOM BLANK - 1/64 STOCK
WEIGHTS
WING .038
M. STICK .018
PROP .019
TAIL .010
MOTOR .053
TOTAL .138
APPROX. OUTLINE
PROP 16" DIAM. CARVED FROM
QUARTERGRAINED
.020-WIRE THRUST BEARING
- POWER -
-BROWN
2000 TURNS ON RECORD FLIGHT
MOTOR STICK BLANK - 1/64 STOCK
OPEN - CLASS C
WORLD RECORD
INDOOR TRACTOR
TIME - 22m 59.4s
DESIGNED BY
CARL GOLDBERG
MADISON WIS.


COVER INDIVIDUAL SECTIONS BEFORE JOINING
CUT TRAILING EDGE FOR TAPER
MICROFILM COVERED
FRONT 1 1/2 REAR 1 3/8
3/64 STOCK
FRONT & REAR PLUGS
PROP & BLANK 1 1/2 x 7/8 x 12
POWER 38 x 7/64 BROWN 2000 TURNS ON RECORD FLIGHT
WEIGHT TABLE
FUSELAGE — .050
WING — .021
TAIL — .014
PROP & PLUG — .018
MOTOR — .065
TOTAL — .170 oz
WASHER
1/8 WIDE SUPERFINE PAPER BRACING
NOTES ON FUSELAGE
LONGERONS 1/20 HARD BALSA
CROSS BRACE WITH PAPER
THEN COVER WITH MICROFILM
(THIS METHOD WAS ORIGINATED BY John Young)
LANDING GEAR TREAD 8"
.010 PAPER
1 1/2 DIA.
TAIL BOOM - 1/64 BENDING STOCK
- TAIL SURFACES - COVERED WITH MICROFILM
F. Zaic
SENIOR - CLASS B
WORLD RECORD
INDOOR CABIN FUSELAGE
TIME - 12m 23.5s
DESIGNED BY
HERBERT GREENBERG
NEWARK N.J.

SOME TECHNICAL NOTES ON THE PRESENT INDOOR AIRFOIL

Being the results of Aerodynamic experiments with eight single surface airfoils.

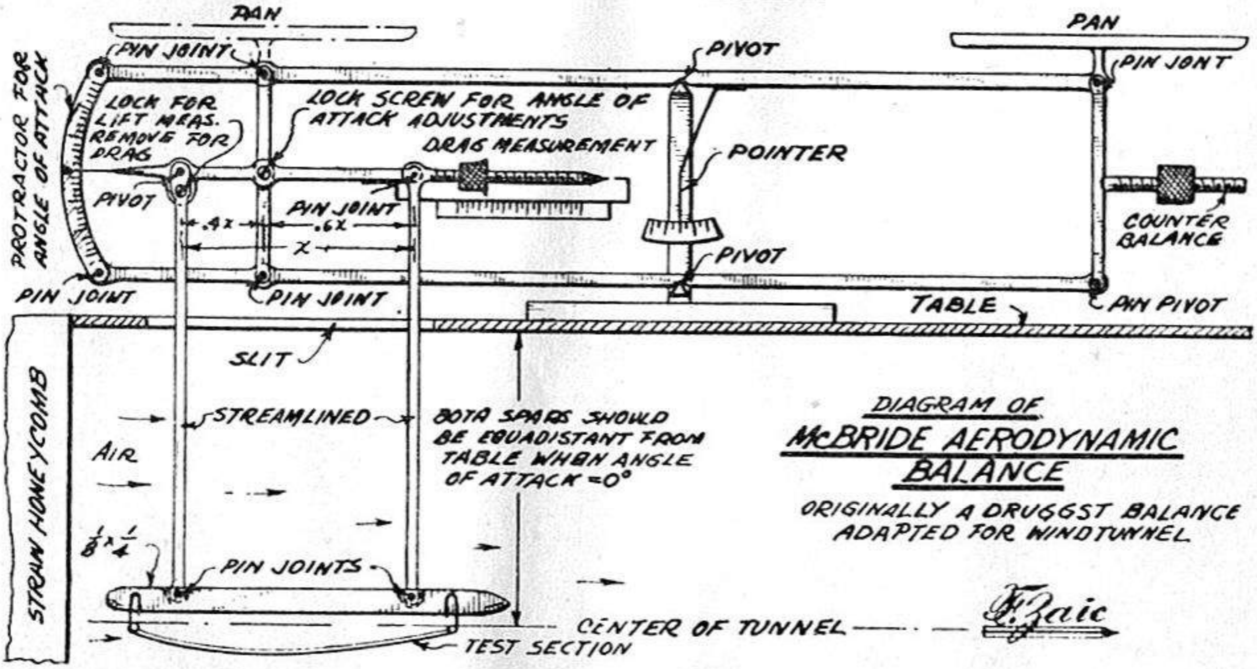
by J. Wallace McBride

The National Advisory Committe for Aeronautics (N.A.C.A.) has published numerous reports on the aerodynamic characteristics of airfoils, none of which are acceptable to the present indoor expert. (R.E.F. 1) Endeavouring to remedy this situation the author began in 1931 to test the single surface airfoils of the "Seven Outstanding Tractors of 1930." (R.E.F. 2) Work was begun using free flight tests but the method was soon abandoned because of the larger number of variables involved. In an attempt to eliminate some of these a small windtunnel was built and placed in operation.

Power for the tunnel was supplied by a one-sixteenth horsepower, rheostat controlled, electric fan. Air was forced through a stiff paper transition piece, going from 13 inches in diameter at the fan to a honeycomb 14 x 5 inches at the entrance to the working chamber. One and one- half inch lengths of soda straw piled and glued on top of one another formed the honeycomb, the purpose of which was to bring the air into the working chamber in parallel streams. (See drawing.)

The aerodynamic balance mounted on the top of the working chamber was of the pin jointed parallelogram type. Lift was measured by an old druggist's balance which had the drag balance mounted on one upright arm. The drag arm was so mounted that its position could be varied at will and then locked in position. The angle of attack which was controlled by this movement was read off a protractor attached to the same upright. Thus one could control the angle of the test section without disturbing it. (See drawing of the balance.)

The test sections were constructed according to current model building practice. Weight being no objection the sections were built very substantially. The tissue covering was supported by, one inch spaced, hard balsa ribs faired into one-sixteenth diameter (being the mean size of the average indoor tractor spar) pine spars Sag at the tips was prevented by airfoil braces similar to those now used in multiple covered microfilm wings. The very low aspect ratio 3.44 was necessary in order to get a chord large enough to give a Reynold's number approaching that of flight.



The test sections were mounted inverted on the drag balance clip arm (1/8 x 1/4, cross section) by Pond type double grip clips. The lift balance was then counterbalanced for the weight of the section with the power off. The test section was then tested to see if it was on the same plane as the top of the test chamber, by taking offset measurements from the spars, when the angle of attack indicator read zero. The power was then turned on and the airspeed obtained. There being no micro-manometer available the airspeed was obtained by mounting a square flat plate normal to the airstream and then recording the drag. Speed was obtained by solving the equation:- $\text{Drag} = C_d \frac{\rho}{2} S V^2$ (Use of this type explained later.) with the drag coefficient (C_d) taken as 1.040 for a plate 10 cms. square (REF. 3 & 4) The test section was then replaced and its angle of attack again checked. Readings were taken for lift with the drag arm locked. The process was repeated for every two degrees throughout the working range. The power was then shut off and the incidence of the test section again checked, If the test section was found to have shifted the process was then repeated.

The tests were carried out either in the mid afternoon or about 4 A.M. in an effort to reduce the error resulting from variations in airspeed due to changes in the power loads on the power line. Comparison of the results with those of the N.A.C.A. have led the author to believe that the airspeed of 7 f.p.s. is a little too great. Although the error may be largely due to the low Reynold's Number. A free flight test with another single surface airfoil gave a C_l of 1.4 at $1^\circ\alpha$ so the error is probably not great. He, however, hesitates to guarantee the accuracy and suggest that the reader test his own airfoil in flight by obtaining speed. It is then possible to calculate the lift coefficient for the angle at which the wing was flying. With this data it is only necessary to transpose the lift curve so it passes through the point obtained by the flight test. The drag curve will also be transposed but the L/D ratio will remain the same. Should anyone carry out such a test the author will be glad to hear the results or if information is desired as to the method he will be glad to be of assistance.

The sections treated were those supplied by the A.M.L.A. in their booklet (Ref. 2). There are in addition two sections developed by the author and two others tested elsewhere that will be of interest, and are included for comparison. The sections are called by the names given them in the booklet although correspondence with some of the gentlemen have shown that the section flown by them were considerably different.* For example, the section shown to be that of Carl Goldberg varied by more than 3/32. The section had a thinner maximum ordinate and was somewhat more bulbous at the entering edge.

The centre section airfoil of Fay Stroud and that of Samuel Balkan were practically identical and gave such a poor showing in the free flight tests that they were left out of the test program. The airfoil known as the B-6 was an airfoil used by the author in 1931 and was the forerunner of the B-7 which was developed as a result of these tests. The aerodynamic characteristics of these airfoils are presented in the standard form. It should be noted though that the Göttingen section and the Flat Plate are plotted to one half the other scale.

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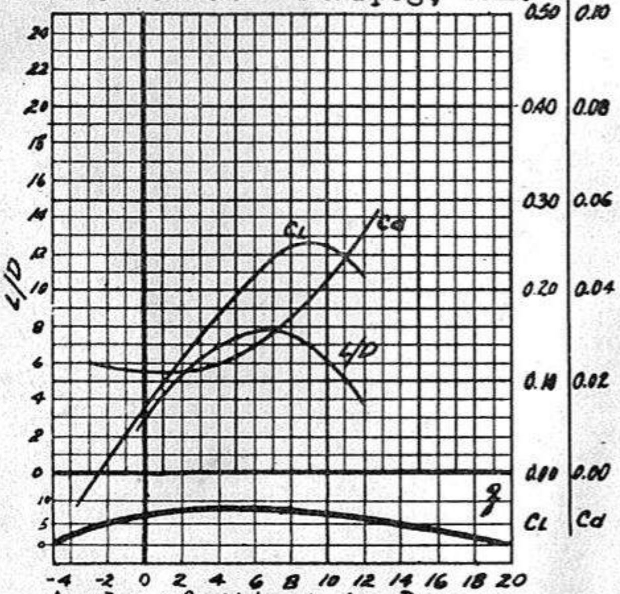
* The author wishes to thank Ray Thompson and Carl Goldberg for their aid and courtesy.

TABLE OF GEOMETRIC CHARACTERISTICS OF THE AIRFOILS

Name	Ordinates and Positions in Percent of Chord											
	0.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	100.
Ray Thompson	0.0	2.30	4.00	6.20	7.50	7.75	7.40	6.75	5.75	4.10	3.60	0.0
Carl Goldberg	0.0	2.70	4.60	6.80	8.00	8.40	8.00	7.00	5.90	4.30	2.30	0.0
Fay Stroud (tip)	0;0	3.00	4.60	7.00	8.10	8.20	7.90	7.00	5.70	4.10	2.30	0.0
L. Hankammer	0.0	3.90	4.75	6.80	8.00	7.95	7.20	6.25	4.90	3.50	1.90	0.0
Jack Fisher	0.0	4.25	5.00	7.80	9.00	9.20	8.80	7.20	5.80	4.00	2.30	0.0
Ernie McCoy	0.0	2.70	4.50	6.80	7.90	8.10	8,00	7.20	6.00	4.60	2.75	0.0
McBride B-6	0.0	2.90	5.10	7.40	8.25	8.30	7.90	6.90	5.60	3.90	2.00	0.0
McBride B-7	0.0	2,35	4.40	6.70	7.80	8.30	7.90	6.90	5.60	3.90	2.00	0.0
Göttingen 417a	0.6	2.86	4.28	5.70	6.48	6.53	6.10	5.38	4.38	3.10	1.60	0.0
Flat Plate	0.5	0,50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

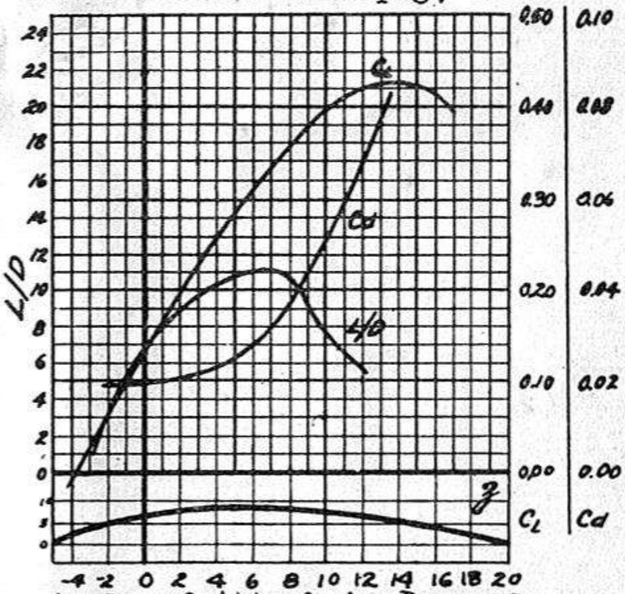
AERODYNAMIC CHARACTERISTICS OF SINGLE SURFACE AIRFOILS

Name of section: Ray Thompson
Wind velocity: 7 f.p.s.
A.R. test section: 3.44
Tested by; McBride, March 1932
Where tested: Winnipeg, Can.



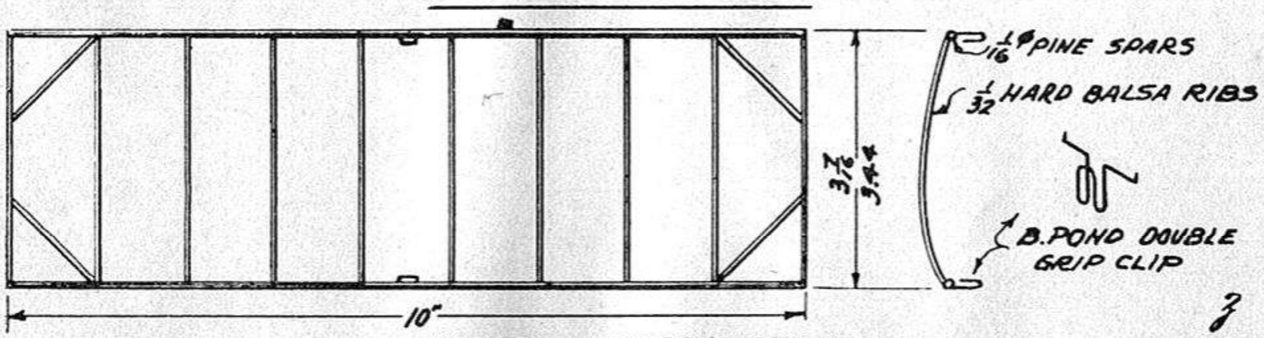
Angle of Attack in Degrees

Name of section: Carl Goldberg
Wind velocity; 7 f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.



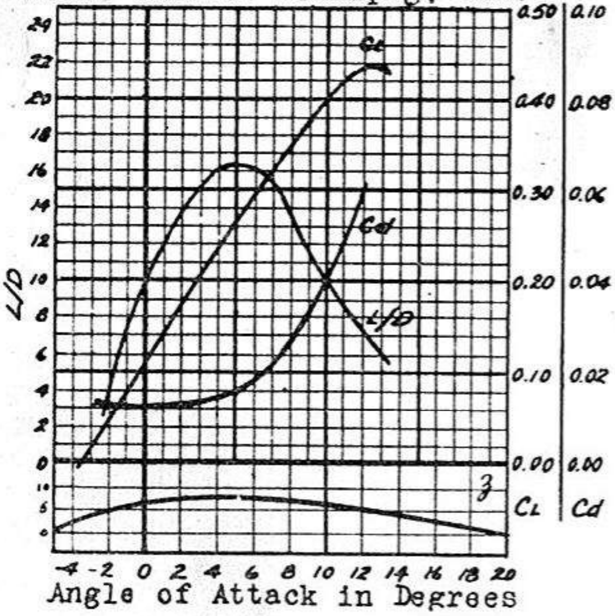
Angle of Attack in Degrees

Coefficients are Absolute

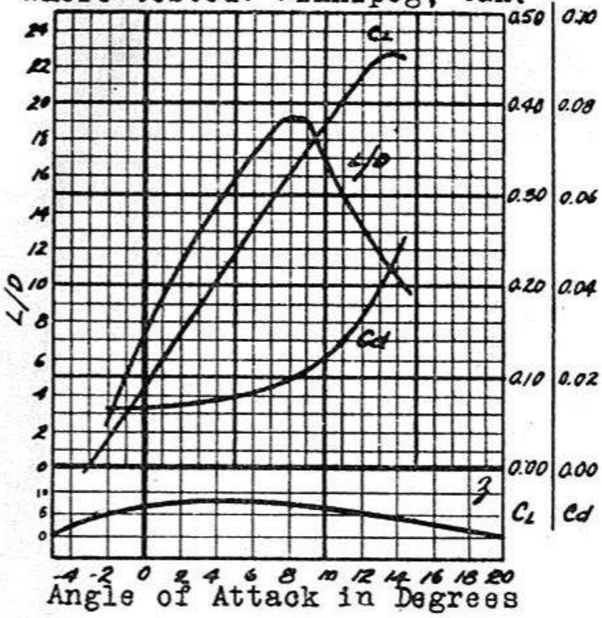


TEST SECTION CONSTRUCTION

Name of section: Fay Stroud
Wind velocity: 7 f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.

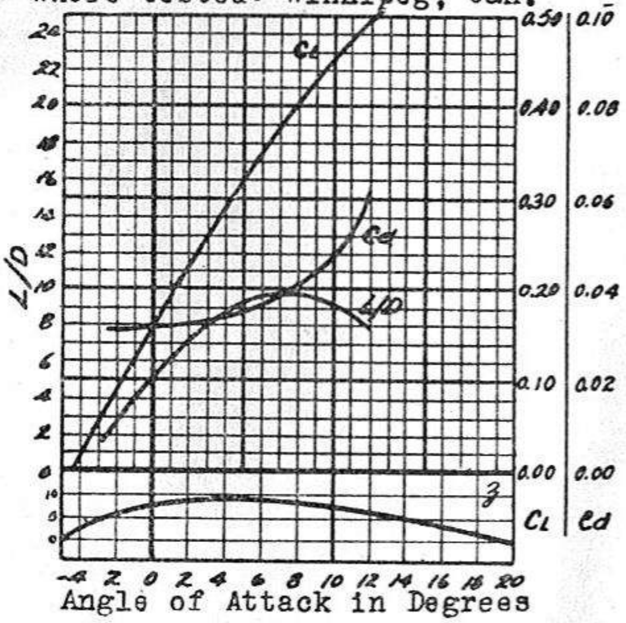


Name of section: L. Hankammer
Wind velocity: 7 f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.

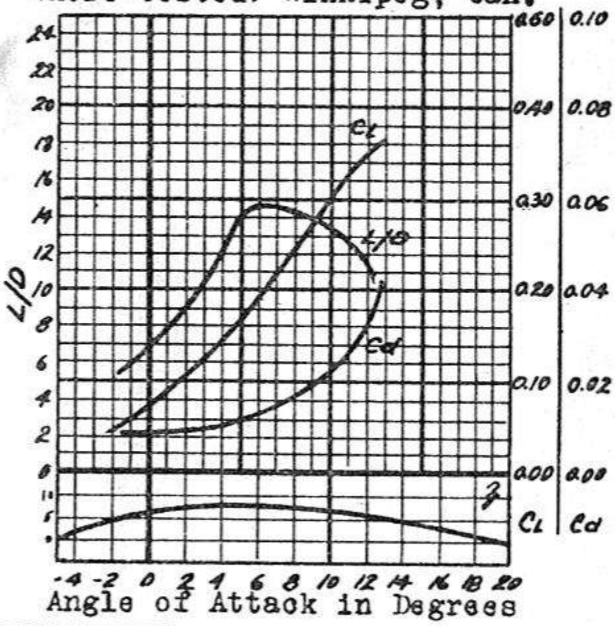


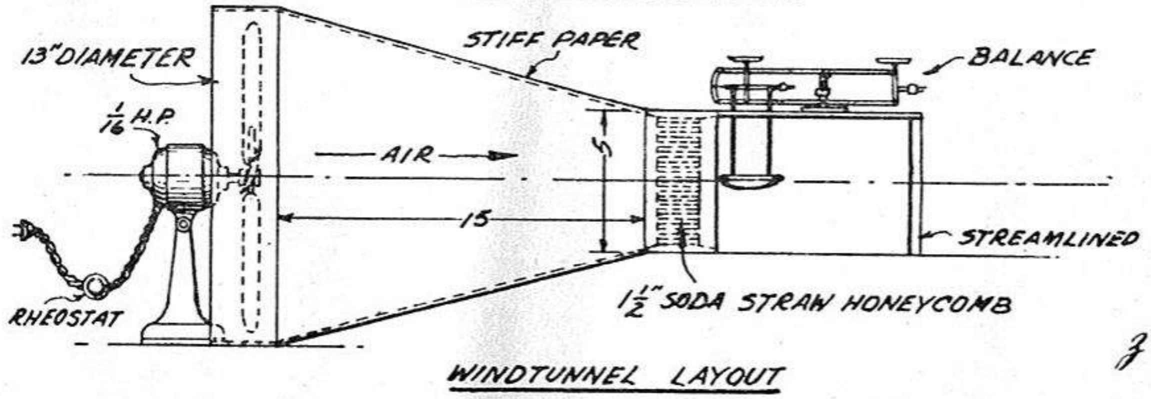
Coefficients are Absolute

Name of section: Jack Fisher
Wind velocity: 7 f.p.s.
A.R. test section; 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.



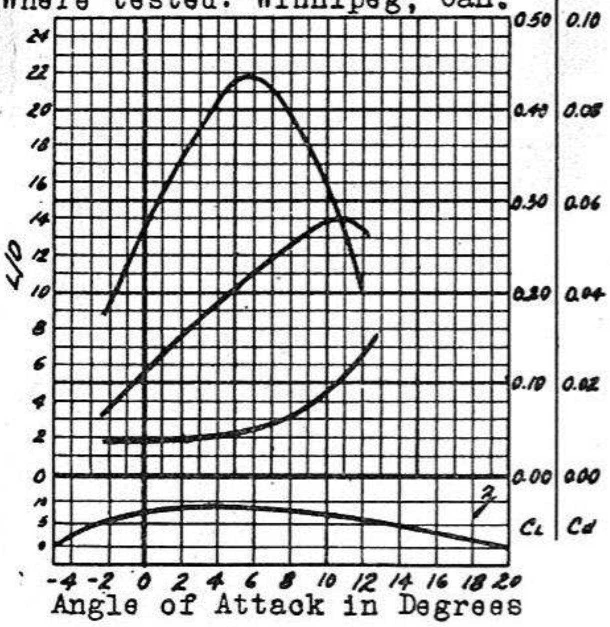
Name of section: Ernie McCoy
Wind velocity: 7 f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.



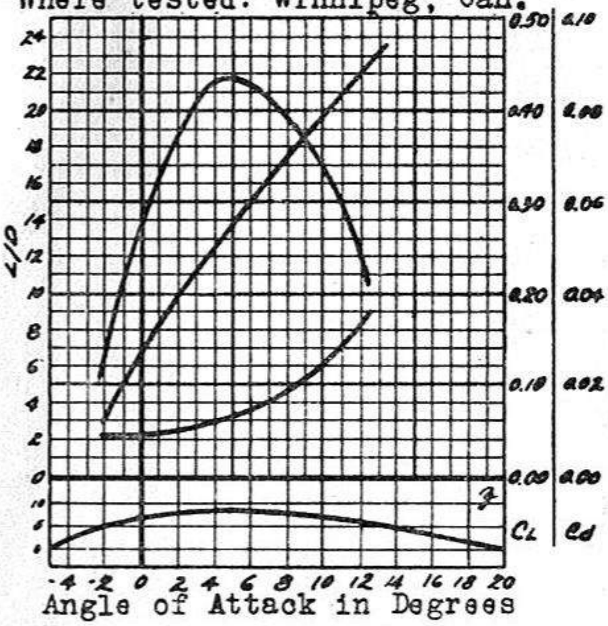


WINDTUNNEL LAYOUT

Name of section: McBride B-6
Wind velocity: ? f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.

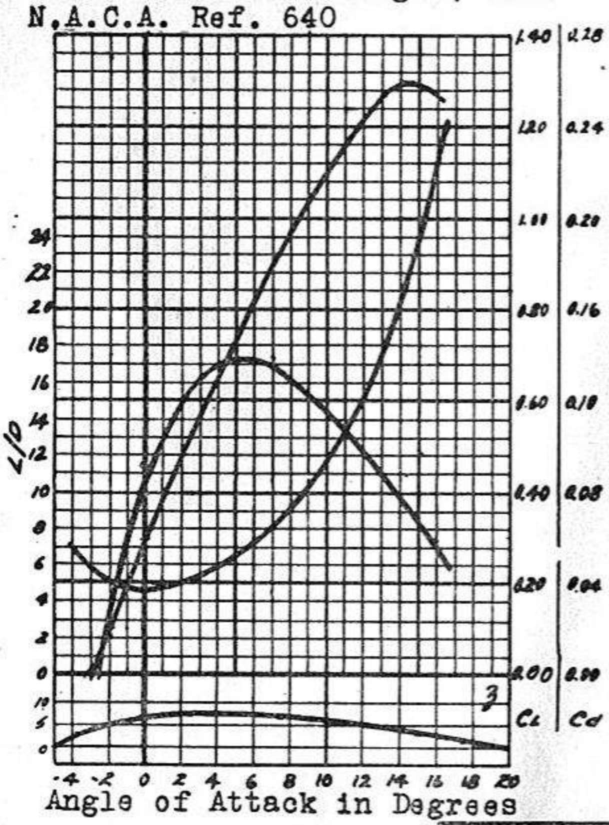


Name of section: McBride B-7
Wind velocity: 7 f.p.s.
A.R. test section: 3.44
Tested by: McBride, March 1932
Where tested: Winnipeg, Can.

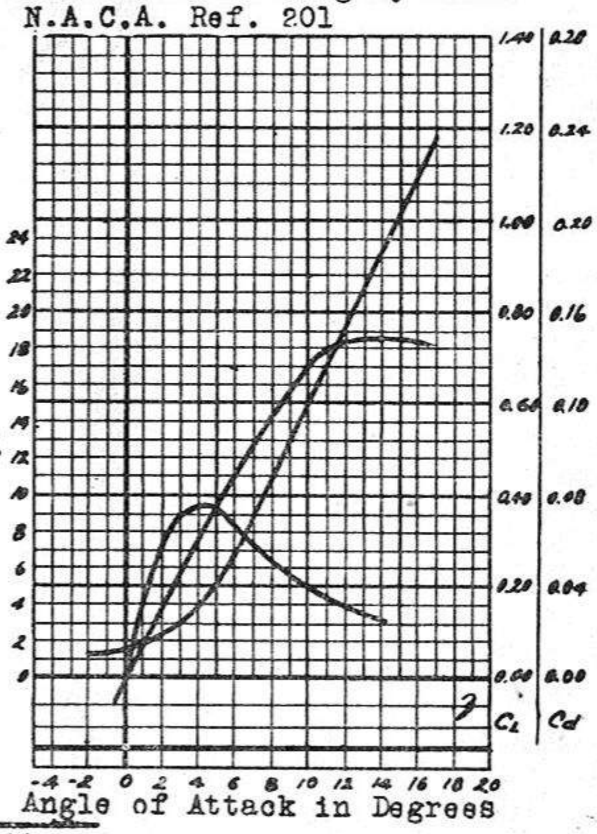


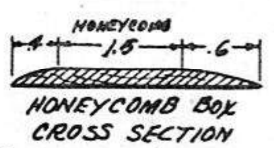
Coefficients are Absolute

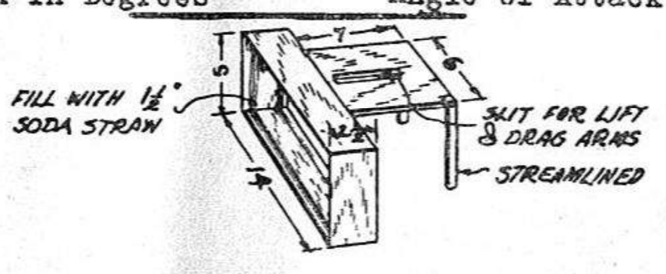
Name of section: Göttingen 417a
Wind velocity: 98.4 f.p.s.
A.R. test section: 5/1
Where tested: Göttingen, 1926
N.A.C.A. Ref. 640



Name of section: Flat Plate
Wind velocity: ?
A.R. test section: 5/1
Where tested: Langley Field
N.A.C.A. Ref. 201







WORKING CHAMBER

Some of the readers may not be familiar with this system of coefficients. The system is that used by the N.A.C.A. and is known as the Absolute system. The coefficient of lift is denoted as Cl and the coefficient of drag Cd.

The lift equation for this system is: $\text{Lift} = Cl \frac{p}{2} S V^2$

The drag equation for this system is: $\text{Drag} = Cd \frac{p}{2} S V^2$

Where p = .002378. The density of the air.
S = the effective area of the wing, square feet.
V = the speed of the air, feet per second. (f.p.s.)

It should be noted that this system of coefficients hold for any consistent system of units, such as the English or the Metric.

Conversion factors are presented here in case one wishes to compare the airfoils with those published using other systems.

$Cl = 2\ Lc = 391\ K_L = .01$ German system
$Cd = 2\ Ld = 391\ K_D = 01$ German system

For the benefit of those not acquainted with the use of Absolute Coefficient Systems the following design is given.

EXAMPLE 1.

Type of aircraft: Indoor Tractor, weight complete .08 oz.
Effective wing area: 100 square inches.
Wing section ie. airfoil: Göttingen 417a.
Angle of attack: 8 degrees 40 mins.

Note the angle of attack is the angle of incidenee between the wing and the airflow. The angle of incidence is the angle of inclination between the wing and a fixed line in the aircraft usually the line of thrust.

Lift Coefficient by chart: 1.00=Cl
Air density 0.002378 at 59 degrees F. and 29.92 inches of mercury.

As the conditions mentioned above are the average of the conditions in the temparate zone one will not be greatly in error it density corrections for change in temperature and pressure are not made.

$$\text{Lift} = \left[1.00 \times .0012 \times \frac{100}{144} \times V^2\right] = \left(L = Cl \frac{p}{2} S V^2\right)$$

It is assumed that there is no down or up load on stabilizer at this angle of attack.

$$\text{Therefore-}\ .08 \times .0625 = 1.00 \times .0012 \times \frac{100}{144} \times V^2$$

(.08 oz.=weight of the model) (.06251lbs.=Cd at 8^0 40')

Solving for V one gets:- V=Root of 6.26 or 2.5
Therefore speed in level flight at 8 degrees 40 mns. is 2.5 f.p.s

Many model builders will question the use of data of this kind in the design of indoor models, and in an endeavor to answer them, these last paragraphs are written.

One of the major uses of scientific information of this kind is that one may compare wing sections and find the effect of making small changes. Thus he will know that flattening out a section between 0 and 30% of the chord will, if carried out within reasonable limits, increase lift and efficiency, thus producing a better endurance airfoil (B-6 and B-7) while humping an airfoil at the 40% station will increase at the expense of efficiency. (Jack Fisher.) Thus by careful comparison of the characteristics of section one may finally develop a very superior airfoil.

Data of this kind is most useful in design work as it is possible to make preliminary endurance calculations, calculate changes in possible duration due to changes in wing area, incidence etc. An example of its use in this kind of work is given below.

EXAMPLE 2.

An indoor tractor of 100 square inches of area was being flown at 6 degrees attack. A check of values of $\frac{Cd}{Cl}$ (One of the criteria for an endurance airfoil. Should be a minimum. (REF.5) of the airfoil has shown that 9 degree is a better angle for the airfoil Would this setting improve duration?

Area: 100 sq. in.
Airfoil: Gött. 417a.
Flying weight: 0.10 oz.

Cd of stick etc.: 0.0824
(this includes area.)
Available energy: 35.0 ft.oz.

6 degrees attack	9 degrees attack
$V^2 = \frac{(0.10 \times 0.0625 \times 100 \times 2)}{(0.8 \times 144 \times 0.0024)}$	$V^2 = \frac{(0.10 \times 0.0625 \times 100 \times 2)}{(1.02 \times 144 \times 0.0024)}$
V = 2.12 f.p.s. Cl at 6 degrees being 0.08 L/D at 6 degrees is 15.2	V = 1.88 f.p.s. Cl at 9 degrees being 1,02 L/D at 9 degrees is 14.1
Motor and stick drag $\frac{(0.0824 \times 0.0024 \times (2.12)^2}{(0.0625 \times 2)} = 0.00715$ oz.	Motor and stick drag $\frac{(0.0824 \times 0.0024 \times (1.88)^2}{(0.0625 \times 2)} = 0.00578$ oz.
Wing drag is $\frac{0.10}{15.2} = 0.00658$ oz.	Wing drag is $\frac{0.10}{14.1} = 0.00707$ oz
Total drag 0.01373 oz	Total drag 0.01283 oz
Power used for flight 0.01373 x 2.12 = 0.02911 ft.oz. per sec.	Power used for flight 0.01283 x 1.88 = 0.02412 ft. oz. per sec
Possible duration $\frac{35.0}{0.01373 \times 2.12} = 1202.4$ secs.	Possible duration $\frac{35.0}{0.01283 \times 1.88} = 1452.3$ secs.

This is an improvement of 20.7% resulting from using the proper wing adjustment. This is an interesting calculation in view of the present trend to reduce the angle of attack in order to reduce resistance coefficient forgetting that the power required depends greatly on the aircraft's speed.

In conclusion the author wishes to state that he believes that flights of an hour or more will be possible in a few years if the model designer pays careful attention to the science of low speed aerodynamics, to which he hopes this article will be a contribution.

REFERENCES

1. N.A.C.A. Technical Reports Nos. 93, 124, 182, 244, 286, 315, 460.
2. "The Seven Outstanding Tractors of 1930." Airplane Model League of America data published by Geo, D. Wanner, Dayton, Ohio. Page 7.
3. Eiffel, "Resistance de l'air at Aviation" Hunsakar translation. Page 38.
4. Engineering Aerodynamics, Diehl. Page 65.
5. Simple Aerodynamics, Carter. Chapter on airfoil selection.

RUBBER MOTOR

No attempt has been made to test rubber for its horsepower as such test have to be extensive and made with accurate instruments to be of any use. Besides, knowing the power will do us no good if we do not know just how much power we need for a certain model. However, the author has few ideas and it is possible that we might have this information next year. At present all that can be said is to use enough power to give the ship a steady climb. Of course, the model must be properly adjusted for the most efficient results. It would not do to have a model fight itself.

If a model flies well on first wind and then just sort of mushes on other flights it might be because the rubber was powerful enough on the first winding and then lost its pep. Just add two strands at a time until the model comes down dead stick on 200 turns. Sometimes when the model seems to be perfectly adjusted but still stalls addition of an extra strand will do wonders. It is much better to have the model climb few thousand feet in a minute than to have it flutter just above the ground for two minutes. The chances for a high climber to hook unto a thermal are much better. Of course, the more streamlined a model is; less rubber it needs, and if the same amount of rubber is used on a streamlined model as on the conventional design, the difference in performance will surprise you. The streamlined model will leave its Resistance brother way behind.

The following turn test were checked by three experts, and they represent the number of turns that may safely be put into the rubber. On two strand test the rubber was streched 5 times, while in the multiple strands it was streched as much as possible. Two prewinds were given: First; about half of total winds and streched about a half of the final winding. Second; about 2/3 turns and 2/3 stretch. On the final winding the rubber was wound ½ of its capacity at standstill and then slowly coming in. The point is that the rubber should always have some elasticity, about 2 to 3 inches. Just watch an expert wind: he winds for a while, and then feels how tight the motor is. Using this method the maximum winds can be stored as the rubber is kept just under its breaking point. You can only get the feel by experience, but keep the above rules in mind and you will be able to get the number of turns as shown on the table.

Basic Weight:- 1/8 x 1/30 Brown. 0.00194 oz. per inch.
1/8 x 1/32 Black, 0.00166 oz. per inch.
Other sizes proportional.

Lengthening coefficient approximately .01 when rubber wound maximum.

RUBBER WIND TESTS FOR TURNS PER INCH

Rubber lubricated, prewound and wound with winder

SIZE	1/32	3/64	1/16	5/64	3/32	7/64	1/8	5/32	3/16
1/32 BLACK	185				103		94		75
1/30 BROWN	215	188	150	140	130	122	115	108	94

STRANDS	4	6	8	10	12	14	16
1/32 BLACK	55	44	42	40	37	35	32
1/30 BROWN	65	55	50	48	40	38	36

THE END