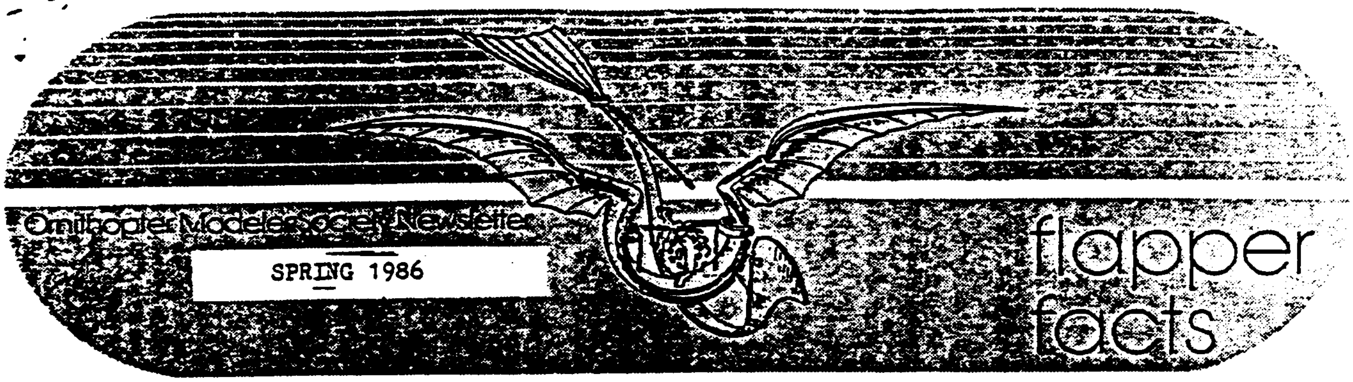


SPRING 1986

VOLUME III NUMBER II PATRICK J. DESHAYE, Ed.

FOND FAREWELLS

Founding the OMS and serving as its first publications editor has been a great pleasure and a wonderful source of pride for me. In the last few years I have watched our club grow from a nucleus of perhaps a dozen enthusiasts busily exchanging letters to a chartered aeromodeling organization comprising nearly eighty members worldwide. OMS now provides publications to inform (Flapper Facts), instruct (OMS Design Manual) and to facilitate communication (mailing list of members) among members. A whole library of reprint literiture is made available to members through their intercooperation in the SASE COOP. There is always a challenge for any member brave or creative enough to enter an OMS-sponsored contest. By saving her from neglect, the OMS has truly saved the mechanical bird from extinction.

This will be my last issue as your publications editor. Until a new full-time OMS publications editor volunteers, Roy and Shirley White will take on responsibility for at least the Summer issue... this, I hope, will feature plans of the White's winning outdoor machine. Please show Roy and Shirley as much courtesy and cooperation as you have me.

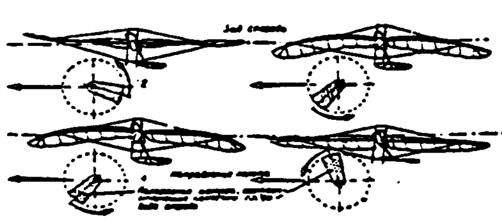
True, Pat

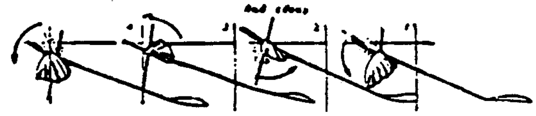
IN THIS ISH

OMS is honored by the membership of John S. White of England, recruited recently by Reg Parham. The importance of insights to modern ornithopter modeling cannot be overestimated, as he is the true father of the phased biplane ornithopter. For this reason, his Nov. 1955 Model Aircraft article is reprinted here in its entirety. White wishes his readers to beware of 'fig. 2' which is erroneous: both upper wing conrods should connect to the inside crank throw. Following this, please find Parham's Aeromodeller article from just after the Erbach postal contest, in which he very correctly predicts a winning future for the White-type bipe. Both of these articles were submitted by the indefatigable Warren Williams.

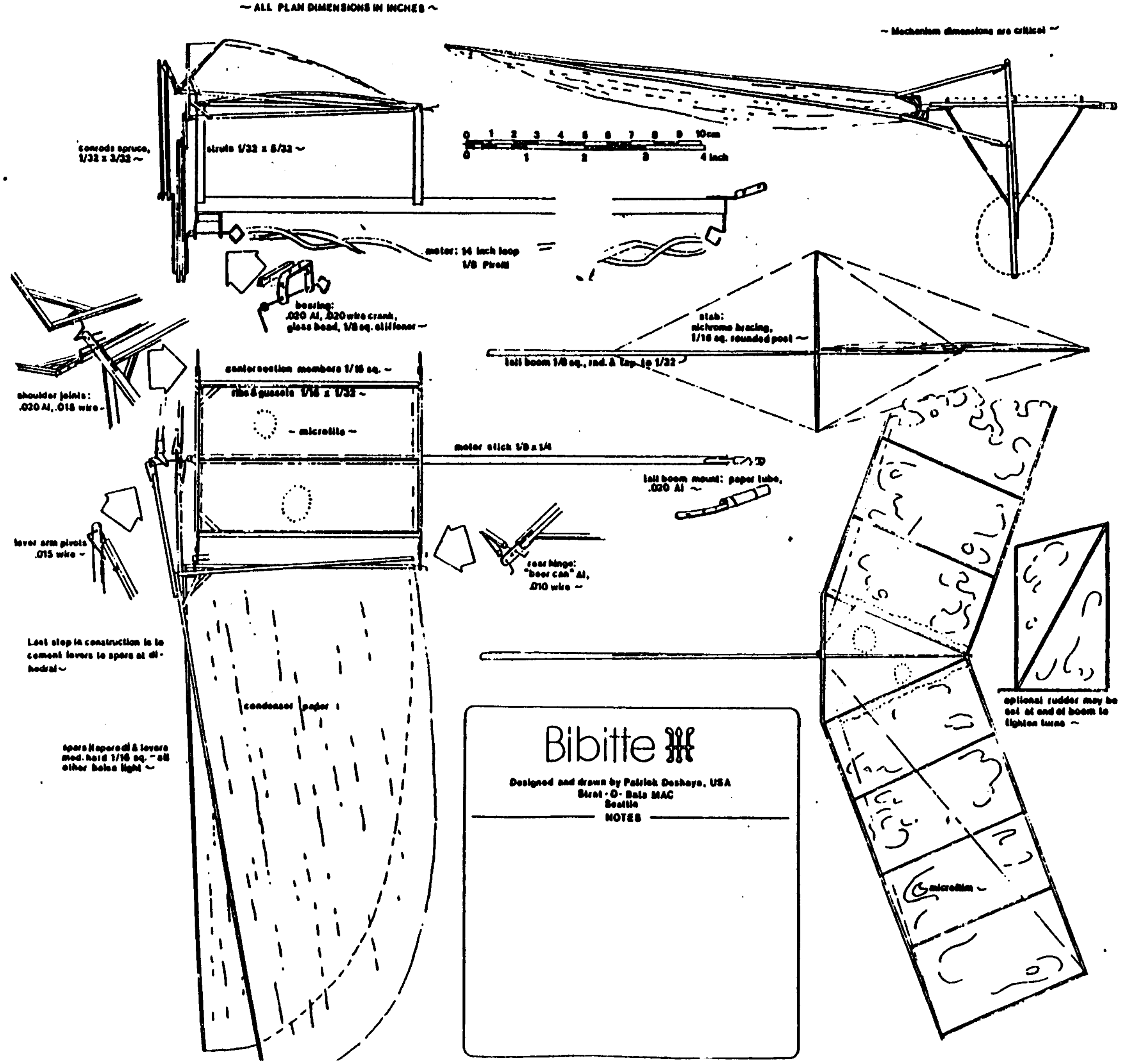
Les Garber has already been featured in the last two issues of FF, but what can I say? The man has a positive genius for conceiving, building and flying the most original designs around and getting amazing duration to boot. Leave it to Garber to use fuselage reaction to his advantage while everyone else tries to escape it...

Also included are some old and outdated plans from Hewitt Phillips (1939) and me (Deshaye) strictly for ~~laughs~~ historical perspective.





-Illustration taken from RAE translation "Models with Flapping Wings" available thru SASE COOP


~ ALL PLAN DIMENSIONS IN INCHES ~
~ Mechanism dimensions are critical ~
concede spruce, 1/32 x 3/32 ~
struts 1/32 x 5/32 ~
0 1 2 3 4 5 6 7 8 9 10cm
0 1 2 3 4 inch
motor: 14 inch loop 1/8 Pirelli
bearing: .020 Al, .020 wire crank, glass bead, 1/8 sq. stiffener ~
stab: nichrome bracing, 1/16 sq. rounded post ~
tail boom 1/8 sq., rnd. & tap. to 1/32 ~
centersection members 1/16 sq. ~
ribs & gussets 1/16 x 1/32 ~
~ microfilm ~
shoulder joints: .020 Al, .015 wire ~
motor stick 1/8 x 1/4
tail boom mount: paper tube, .020 Al ~
lever arm pivots .015 wire ~
rear hinge: "beer can" Al, .010 wire ~
Last step in construction is to cement levers to spars at dihedral ~
condenser paper
optional rudder may be set at end of boom to tighten turns ~
spars tapered & levers med. hard 1/16 sq. ~ all other balsa light ~
microfilm ~
Bibitte
Designed and drawn by Patrick Deshaye, USA
Strat-O-Bats MAC
Seattle
NOTES

A SIMPLE TANDEM ORNITHOPTER

The enclosed sketches are for an extremely simple ornithopter suitable for first attempts at flappers. To date I have built two models of this design (1.8 gms and 0.9 gms). The heavy one consistantly does 3 to 4 minutes and the light one 4 to 5+ minutes under a 49 ft. ceiling. The inital climb out is VTO.

The mechanism that drives the rear wing consists of three parts: 1. The crankshaft. 2. Guide pin glued to top of post. 3. The slotted pushrod which is glued to the rear wing. Technically speaking, this mechanism is a Whitworth quick-return mechanism. The slotted pushrod is a significant design improvement over my previous mechanisms in which a solid pushrod traveled within a slot in a guide slot frame.

The slotted pushrod is made from 4 pieces of .020 X .050 bamboo. Glue the pushrod together with CA, drill .040 hole for brass bushing, glue bushing in place with CA, sand carefully, and rub graphite into slot. The crankshaft and pin are made of .020 MW, the crankshaft must be bent carefully. Use small pieces of teflon or brass tubing for spacers on the the crankshaft and pin.

The front wing is mounted to the motor stick via tissue tubes. The wing posts must be made of bamboo (or spruce) or they will snap under the flapping loads. The torque reaction on the motor stick rotates the front wing in a direction counter to that of the rear wing. Note that the front wing is slightly smaller than the rear wing (18 "X 2" compared to 20" X 2.5").

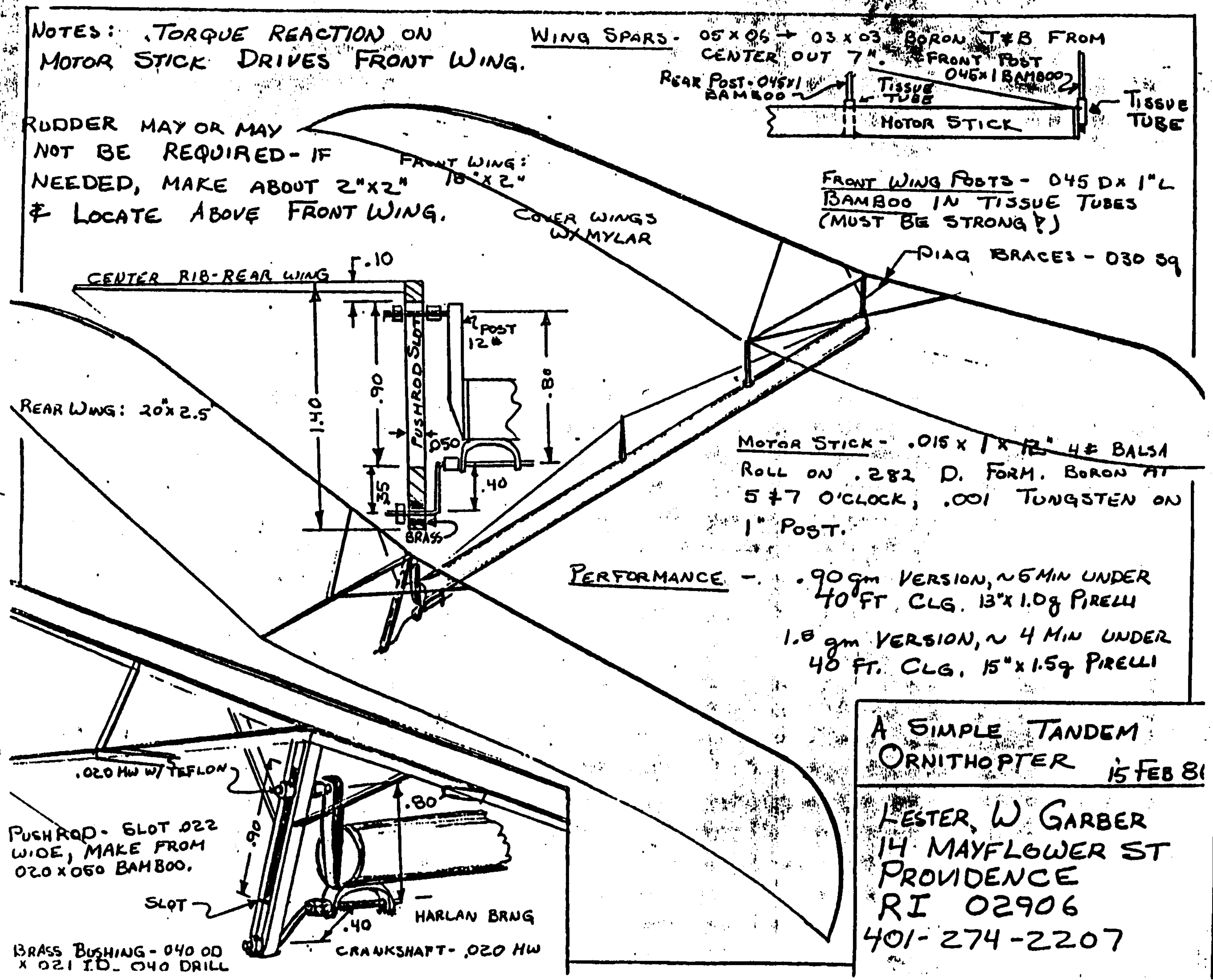
Your model may or may not require a rudder. If it does, make it about 2" high by 2" wide and mount it above the front wing.

The given wood sizes and construction methods will yield a light model. If built carefully, I'm sure this model could be built to .75 grams. A heavier version using a solid motor stick (or tube rolled from .025 sheet) weighing 1.5 to 2 grams will still give respectable flight times.

The flapping angle is determined by the ratio of the crankshaft radius (0.40") and the distance from the crankshaft centerline to the pin centerline (0.80"). For this design the flapping angle is quite small (about 30 deg.) and the flapping rate is quite high (about 200 flaps/min). The flapping rate can be slowed down by increasing the radius of the crankshaft (say to .50") and redesigning the pushrod, but this would require a rubber motor of greater cross-section.

I believe there is much room for experimentation and improvement in this basic design. Still the present design flies quite nicely, is simple in design, and can be built quite lightly.

Lester W. Garber 15 Feb. 86


NOTES: TORQUE REACTION ON MOTOR STICK DRIVES FRONT WING.
RUDDER MAY OR MAY NOT BE REQUIRED - IF NEEDED, MAKE ABOUT 2"x2" & LOCATE ABOVE FRONT WING.
WING SPARS - 05 x 06 → 03 x 03 BORON T&B FROM CENTER OUT 7".
FRONT POST 045x1 BAMBOO
REAR POST - 045x1 BAMBOO
TISSUE TUBE
MOTOR STICK
TISSUE TUBE
FRONT WING POSTS - 045 D x 1" L BAMBOO IN TISSUE TUBES (MUST BE STRONG!)
FRONT WING: 18" x 2"
COVER WINGS W/ MYLAR
DIAG BRACES - 030 SQ
CENTER RIB - REAR WING
.10
1.40
.90
.35
PUSHROD SLOT
POST 12#
.80
.050
.40
BRASS
REAR WING: 20" x 2.5"
MOTOR STICK - .015 x 1" x 12" 4# BALSA ROLL ON .282 D. FORM. BORON AT 5 & 7 O'CLOCK, .001 TUNGSTEN ON 1" POST.
PERFORMANCE - .90 gm VERSION, ~5 MIN UNDER 40 FT. CLG. 13" x 1.0 g PIRELLI
1.8 gm VERSION, ~4 MIN UNDER 48 FT. CLG. 15" x 1.5 g PIRELLI
A SIMPLE TANDEM ORNITHOPTER
15 FEB 81
LESTER W. GARBER
14 MAYFLOWER ST
PROVIDENCE
RI 02906
401-274-2207
.020 HW W/ TEFLON
.80
.90
PUSHROD - SLOT .022 WIDE, MAKE FROM 020 x 050 BAMBOO.
SLOT
HARLAN BRNG
.40
BRASS BUSHING - 040 OD x 021 I.D. - 040 DRILL
CRANKSHAFT - .020 HW

Ornithopters

by J. S. White

The author with one of his earlier ornithopter models which he flew at the British Nationals in 1954.

MY interest in ornithopters, or flapping wing machines, was aroused in 1949 by the plans of Parnell Schoenky's *Flap Happy*.* Rather limited success with this model led me to give considerable thought to the design principles involved, developing such ideas through numerous experimental models aimed throughout at improving performance.

The two main problems to be solved are—first, a method of transferring the power or energy stored in the rubber motor to the wings at a *uniform* rate; and, second, the design of wings which are efficient propellers under power and also capable of sustaining the model in a glide when the motor has run out.

The wings of an ornithopter are its propeller, driven direct from the rubber motor. Thus the problem of coupling is quite different from that of orthodox rubber driven models. Power is transmitted from the motor to the wings by means of a crank and connecting rods, the wings being pivoted to flap up and down. The simple crank system used by Parnell and others—Fig. 1—is inefficient since only one half of the energy stored in the rubber is transmitted to the wings and the wasted power largely produces vibration.

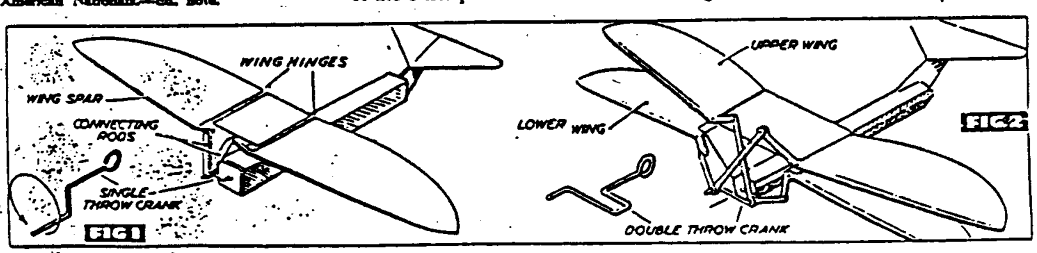
The first step in improving the breed was to study the simple crank system carefully. In the horizontal position, going either up or down, the wings are moving with their greatest velocity and when the crank is moving at the top or bottom point of its revolution the wings have practically no movement. It is at these "dead" points that the crank tends to speed up, resulting in the jerky action and cracking sound characteristic of this type of design.

My first attempt to lessen vibration was to cement two carefully shaped pieces of soft rubber on the upper and lower faces of the noseblock so that the crank rubbed against them at the top and bottom of its circle. It certainly lessened the vibration, but it did not improve performance, simply because it provided only a case of wasting energy by absorbing it by friction. The next step was to consider using two pairs of wings arranged so that the "dead" points of one pair of wings coincided with the maximum speed or "active" points of the other pair.

Designing the crank system for my first multi-winged model was tricky—Figs. 2 and 3—since flapping wings are rather intangible things, confusing to analyse visually. Thus my first job was to plot the motions of each wing graphically. This was done by drawing the crank at various angles and measuring the corresponding angles assumed by the wings. Thus over a complete revolution it was possible to plot the change in angle of the wing with rotational movement of the crank.

Calling the angular displacement of the crank α and the angle assumed by the wings β, a graph of the change in angle of the wing through a complete revolution follows very much the same path as a sine curve—Fig. 4, wing A. Apart from showing the extent of the wing beat, such a curve also shows the angular velocity of the wing and the changing gradient of its slope.

* Parnell Schoenky, of the United States, is one of the world's leading authorities on unorthodox models, particularly ornithopters and helicopters. In addition to numerous past contest successes with such models he recently won the Hiller helicopter trophy at the 1955 American Nationals.—Ed. note.



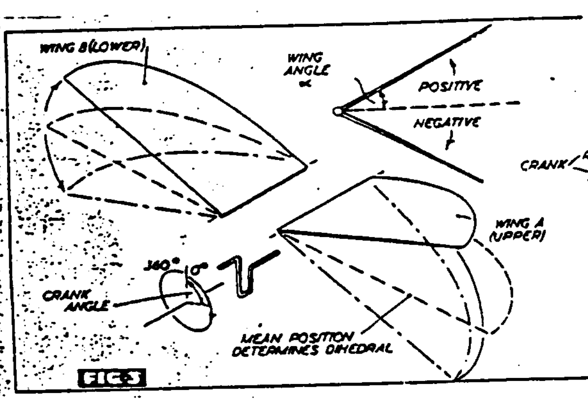


FIG 3

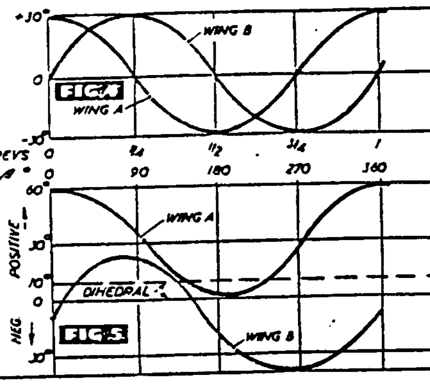


FIG 4
FIG 5

· Adding a second wing pair one quarter of a revolution or 90 degrees out of phase (wing B) means that the point of maximum velocity of the first pair of wings coincides with the point of minimum velocity of the second pair, and vice versa. In other words, one pair of wings is "active" when the other pair reaches a "dead" point.

It is obvious that such a system of paired wings would overlap, so intending to mount one pair of wings above the other—Fig. 3—the curves were redrawn, raising the mean position of one pair of wings and lowering that of the other pair so that they would just meet, or nearly meet at the desired dihedral angle—Fig. 5.

A half-scale modified version of *Flap Happy* was then built, boasting two pairs of wings operated by a double-throw crank. The resulting model had a spectacular performance and was capable of resisting damage in a remarkable way. If it hit the wall instead of the ceiling on its passage across the dining room it was reckoned to be in poor trim. It was a scaled up version of this model that established the current British outdoor ornithopter record and made two consecutive flights of 1 min. 55 sec. and 1 min. 51 sec. at the Northern Heights Gala in 1954.

The fact that the wing beat curves approximate to sine waves can be assumed to be in its favour. Sine waves occur with uncanny frequency in nature—in the fins of fishes, along the wing of a manta ray when it is propelling itself through the water, and in countless other ways. I felt that I could not go far wrong if I copied nature and so redisigned the mechanism to enable the wings to beat with a true simple harmonic motion.

In order to produce this motion it is necessary to satisfy two conditions. The connecting rods must be the same length as the distance between the crank bearing and the wing bearing; and the connecting rods must be parallel to a line joining the crank bearing and the wing bearing at all positions of the crank.

The first condition is easily satisfied by making the connecting rods the correct length and then adjusting the mean position of the wings by offsetting the little-end bearings—Fig. 6. The second condition cannot be satisfied, but a close approximation can be arrived at by pivoting all the wings at the same point and making the throw of the crank very small in proportion to the length of the connecting rods—Fig. 7. This re-

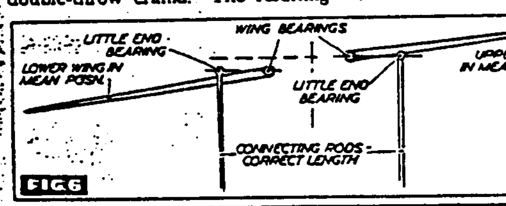


FIG 6

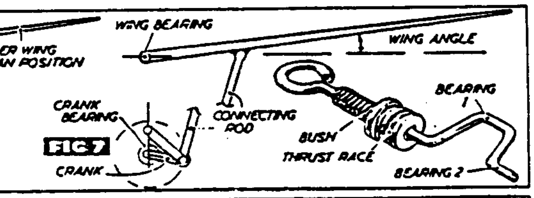


FIG 7

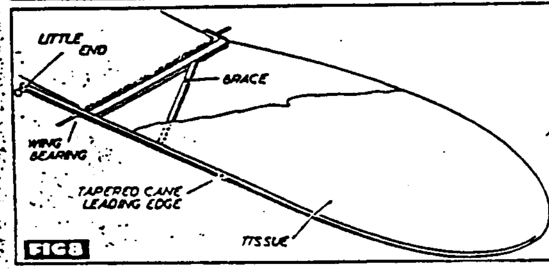


FIG 8

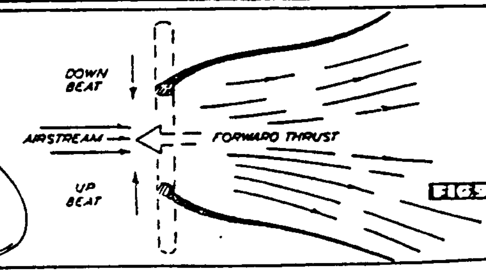


FIG 9

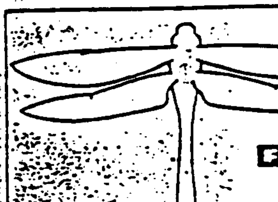


FIG 10

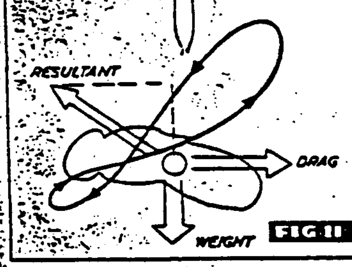


FIG 11

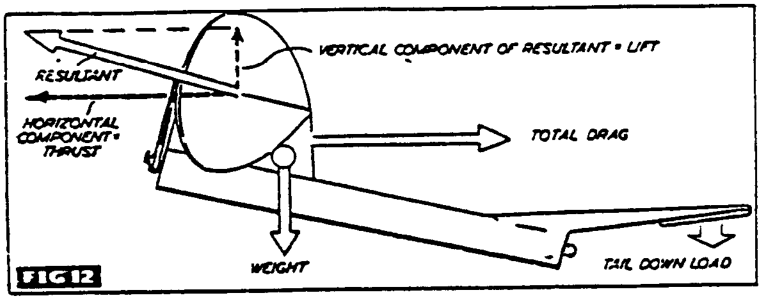


FIG 12

designed mechanism quickly proved, in practice, to be a great advance over the original. The type of linkage used is capable of transmitting energy from the rubber motor to the wing pairs at a uniform rate. The wings beat with remarkable smoothness and the crank unwinds at a regular rate without hesitation or vibration.

Two pairs of wings, then, one pair 90 degrees out of phase with the other pair, and both beating with simple harmonic motion solves the problem of *uniform* power transfer. The major disadvantage of the system mounting one pair above the other is that only one half the total wing area is presented on the glide. There is no reason why this should not be overcome by mounting the pairs of wings in tandem as in the dragonfly. With the mean position of *both* pairs of wings then arranged at about 10 degrees dihedral, full wing area and ample stability is provided for the glide.

This leaves the question of the most efficient design for the wings. Most wings at present in use consist of lightweight tissue with a stiffened leading edge and rigid root member—Fig. 8. In order to understand its action clearly, consider it as a blade of a propeller which instead of revolving continuously has an oscillating motion. On the upward beat the unsupported [illegible] leading [illegible] and, [illegible] shape similar to the concave undersurface of a propeller—a change in pitch being evident from root to tip. At the end of the stroke when the wing changes direction, air pressure billows out the tissue in the opposite direction, changing the wing from a right-handed propeller to a left-handed one, and vice versa. The resultant thrust is in a forward direction, as one would expect from a propeller—Fig. 9. Any perpendicular component on the up beat is cancelled out by an equal and opposite component on the down beat.

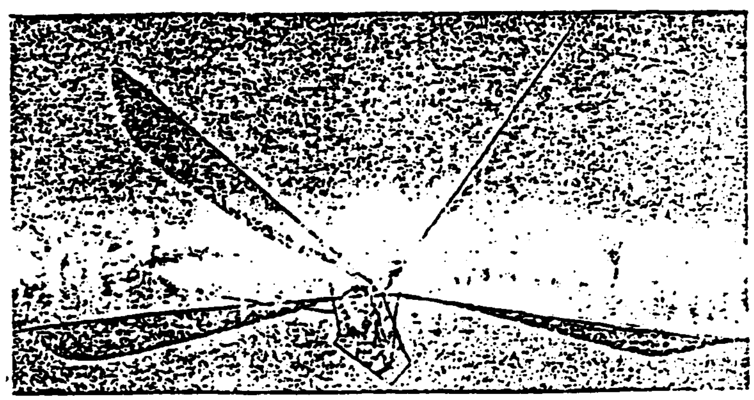
Ron Warring in an article published in this journal in 1953 suggested that if we wanted a successful model ornithopter we would have to start by forgetting about bird flight. I agree that the complicated action of a bird's wing and the function of its feathers would be difficult to duplicate, but I would suggest that a study of insect flight should not be neglected by those interested in the design of flapping wing models.

Contemporary model ornithopter wings are most like those of the dragonfly—Fig. 10. A dragonfly's wing muscles act directly on the wings as on levers, resulting in a simple up and down movement. The reversal of inclination is caused by the pressure of air acting on the wings, which are rigid in front and flexible behind. This change in inclination is not seen when a dragonfly's wing is vibrated in a vacuum.

In less primitive types of insects this change in incidence is chiefly effected by muscular action, the same change in inclination taking place when the wing is cut down to a stump.

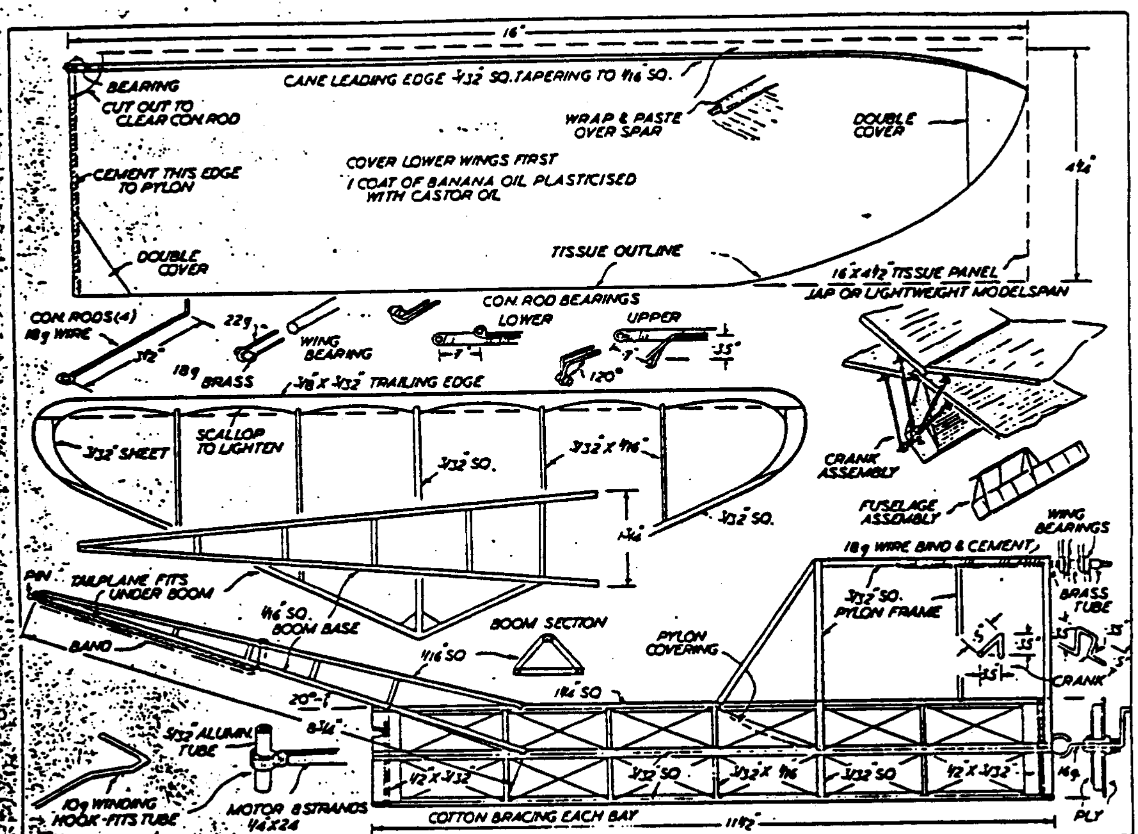
The usual insect wing consists of a membrane stiffened by tubular structures, its flexibility increasing gradually from leading edge to trailing edge. Although this description follows closely that of a model wing there are differences and I would suggest that improvements can be made by duplicating as far as possible the characteristics of a dragonfly's wing. The possible improvements over existing model wings would appear to be :—

(i) There must be a gradual change in flexibility across the width of the model wing. The cane leading edge is not so necessary if the driving mechanism is free from vibration and balsa could probably be used. I would suggest that the wing should have a thin symmetrical section with sufficient lateral flexibility to adopt the shape of an efficient aerofoil under power.



A head-on view of J. S. White's latest ornithopter. The plan is overleaf.

On the upward beat, the unsupported tissue behind the leading edge is forced downward, and, if it is fresh and taut, adopts a shape similar to the concave undersurface of a propeller- a change in



(ii) The longitudinal flexibility of the wing must be such that under power the air pressure forces it to adopt the correct pitch relative to the velocity of the wing through the air, so that with the lateral flexibility just mentioned the wings adopt the shape of an efficient propeller.

(iii) Whilst flexible enough to satisfy (i) and (ii) above, the wing must still be rigid enough to prevent undue flexing on the glide.

There is obviously a great deal of experimenting and development to be done on the design of model ornithopter wings. It is interesting to note, for instance, that the rear wings of the dragonfly beat just before the forward wings so that both wings meet undisturbed air. In other species of insects the trailing edge of the forward wings locks, by means of bristles, to the leading edge of the rear wings, presenting one complete area which solves the problem of the rear wings beating in disturbed air. In others the forward wings beat first and the rear wings follow.

Fig. 11 shows the forces acting on a fly in forward flight. The resultant force from the wings passes through the centre of gravity, giving it a helicopter-like stability. The high angle of attack—something like 50 degrees—must be due to its relatively low power : weight ratio—its flight muscles comprising only about 11 per cent. of its total weight.

Fig. 12 shows my estimate of the forces acting upon a model ornithopter in flight. The apparently unbalanced position of the thrust of the wings is balanced by the negative angle of the tailplane. This is a typical flying position, the tailplane being almost horizontal. The resultant force generated by the wings has a vertical component yielding lift and a horizontal component of thrust to balance the drag.

My latest model, plans of which are on this page, will be a test bed on which to experiment with various types of wings. It should be readily duplicated in the form shown and, in the hands of the average modeller, be capable of turning in flights of over one minute. In expert hands—who knows—a record flight ?

More on Flappers by Reg Parham

The simple rubber powered model ornithopter monoplane concept has changed very little since it was evolved by Penaud over one hundred years ago. Its mechanism comprises a crankshaft rotated by the rubber, which in turn, operates the flapping wing spars via connecting rods. As the wings flap, the covering material which is unsupported at its trailing edge, assumes its own natural section and propels the machine forward in a similar manner to the action of the tail of a fish.

Whilst many sucessful examples of this type of 'flapper' have been built, it suffers the disadvantage of trying to shake itself to pieces under high torque conditions. The reason for this is that only one half of the energy stored in the motor is transmitted to operating the wings and the rest is wasted chiefly in producing vibration. The latter is caused by the speed of rotation of the crankshaft slowing down every time the wing flap reaches the extent of its motion. In addition, to overcome the effect of gravity, the down-stroke is lower than the up-stroke. The overall result is the jerky action and the cracking sound characteristic of the simple model.

Fairy V is a fine example of a biplane ornithopter and owes much of its origins to the work of British modeller John S. White who, in the early 1950's studied the shortcomings of the simple flapper and evolved a series of highly successful outdoor models. Multi-winged machines had been built previously but the idea of two sets of superimposed wings working in opposition and coming together at a predetermined dihedral angle was something new and the improvement in performance quite remarkable. John went a stage further by arranging for a double crank system to operate one set of wings 90° out of phase with the other to more fully utilise the power of the motor and further reduce vibration.

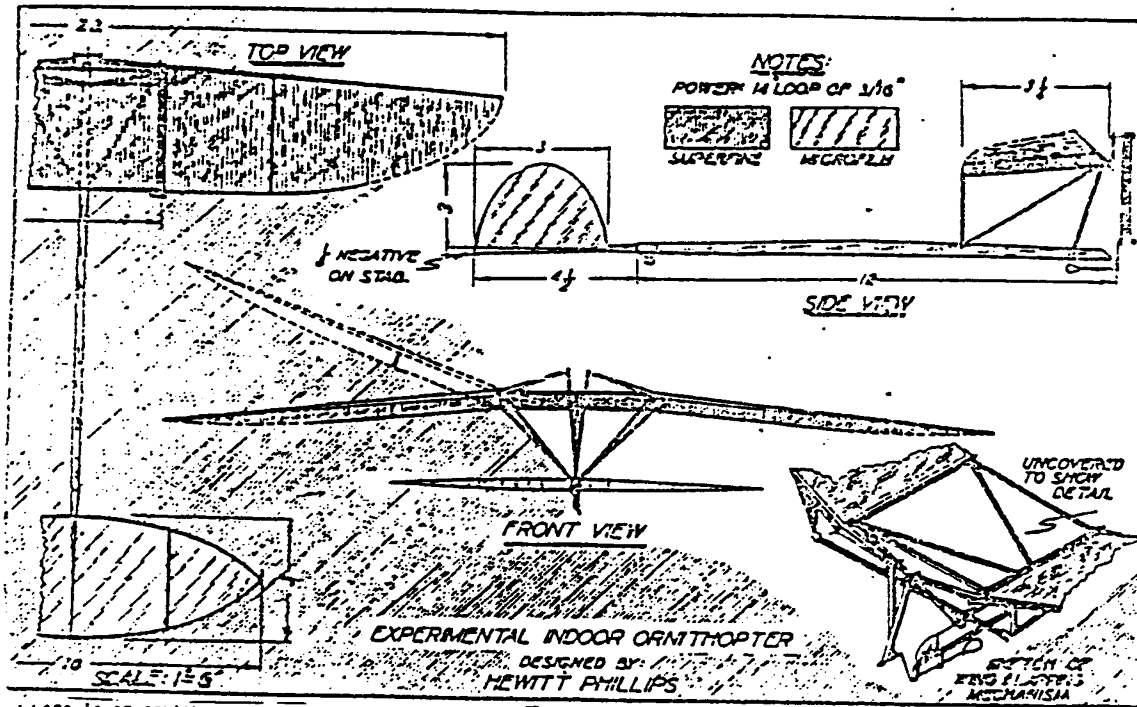
I have built several indoor ornithopters based on John White's principles and, over the years, have demonstrated them to clubs, societies and at the ME Exhibition. The advantages of the biplane over the simple ornithopter are very apparent in that it is quiet and flies smoothly with little or no vibration. There is definitely additional thrust caused by the wings coming together which can be demonstrated by the model being able to climb, nose up, vertically and even hover. It is of interest that in nature, birds and insects are known to clap wings on the upstroke.

The results of the postal contest show the honours between the monoplane and biplane ornithopters to be evenly divided. In spite of a possible weight disadvantage the double 'flapper' is more efficient and should go to the fore. Further contests for the much neglected ornithopter will stimulate further developments and use of new materials making the first 10 minute flight a reality within a year or two.

International Ornithopeter Postal Contest Regulations

Event Definition: An ornithopter is a freely flying model aircraft which derives its lift and propulsion from flapping its wings

- Flights must be made indoors and launched within two metres of the floor.
- The total supporting surface must not exceed 100[illegible]cm
  The supporting surface includes all surfaces to obtain lift or pitch control.
  Areas are measured by traces around surfaces
  The sum of the areas of any fixed supporting surfaces must not exceed one-half the area of the flapping surfaces.
- The model must be powered by strands of extensible rubber only
  There is no restriction on the weight of the model, or on the weight of the rubber which is used.



Here is an ornithopter for the indoor experimenter that has won various honors in low ceilings. A different feature is a "leveling device" which assists the rubber motor to pull the wings downward when the linkage is in its most critical position, thus aiding in unwinding the motor completely.

The motor stick is conventional indoor type made from 1/32-inch sheet - medium hard stock, 7/8-inches wide. The four cabane struts are 1/16 - inch strips rounded. The main wing spar tapers from 1/8 x 1/16-inch (set on edge) to 1/32-inch sq. at tips. The connecting rods are rounded 1/16-inch square strips.

Trailing edge of the wing is 1/16-inch sq. at the center tapering to 1/32-inch sq. about two-thirds the way out to provide a flexible trailing edge. The superfine which has its grain running parallel to the path of flight is unsupported a portion of its length along the trailing edge.

Center section is built from 1/8 x 1/16-in. strips set on edge. The tail surfaces are standard indoor design, a bit stronger than usual to withstand the vibration.

The crank shaft, rear hook, hinges and "leveling device" hooks are of .020 music wire. A double dural thrust bearing is used. The "leveling device" is a rubber band of sufficient power to just balance the wing when the "ornery-flapper" is gliding. The size of the rubber is determined by its ability to make the mechanism function smoothly.

IC-POWERED ORNITHOPTER POSTAL CONTEST UPDATE

The opening of the contest will be announced to the modeling press probably within the year. Because there is no deadline there is no reason the public should be informed before our own. The contest trophy is still in the ceramic-shell investment stage, so general announcement of the contest and rule will occur only after the trophy is ready.

Many thanks to Stan Chilton for donating $20 to the extra prize purse.

Among various comments provoked by the inside announcement was a power-transmission idea from Bob Meuser:

> **Would there be anything illegal about putting a rubber motor between t e IC-engine source and the flapping mechanism?**
>
> **The rubber would act as a torque-leveling device. The power would still come from the IC engine. But the instantaneous power from the rubber will, at certain parts of the cycle, exceed the IC-engine power. The net power still comes from the IC engine, although a severe stretch of the imagination could make such a thing a rubber-power model.**
>
> **Watcha think?**

I think this is a great idea, so long as the engine is continuously airborne and running during flight. Note that the new address for entries is: OMS IC POSTAL, 6401 Wildflower SE, Olympia, WA 98501.

OMS SASE COOP CONTD

The library grows, slowly but surely. Add this to last month's list of available reading material. Just send SASE w/ req. postage to the designated member for each reprint.

POST.	TITLE	DESCRIPTION	MEMBER
44¢	....."Biophysical Aerodynamics" by Ward-Smith	Chapt. 6 of book: "Flapping Flight".......	Lester Garber
44¢	.... Aeromodeller Annual excerpt	"Flapping Wings in Nature and Science" by Herzog...	Robert C Warth
44¢	.....Royal Aircraft Est. Trans., excerpt ...	"Models with Flapping Wings" index, illus.	Hewitt Phillips
88¢	....."Ornithopters: the Greek Connection"...	Technical, ten pages on fuselage motion	Hewitt Phillips

A note to new members:

Back issues of Flapper Facts and the design manual will continue to be available from Roy while supply lasts. For an almost complete backlog, send a 9x12 SASE with $2 postag to the return address on this newsletter.

OMS ROSTER OF MEMBERS

1	REG.T.PARHAM	3 TAYSON W.	MALVERN LINK	WORC.WR141UF	ENGLAND 3107
2	ED.LIDGARD	24722 MARBELLA	CARSON,CA	90745	USA
3	WILL.B.TEFFT	2103 ETON SE #3	ALBUQUERQUE NM	87106	USA
4	WALLACE BROWN	RR 4 BOX 51	LAWRENCEVILLE	ILL. 62439	USA
5	HEWITT PHILLIPS	310 MANTEO AVE.	HAMPTON VA	23661	USA
6	WALTER ERBACH	2979 DUDLEY ST.	LINCOLN NE	68503	USA
7	WARREN WILLIAMS	941 REED DR.	CLAREMONT CA	91711	USA
8	BOB MEUSER	4200 GREGORY ST	OAKLAND CA	94619	USA
9	DAN GARFINKEL	P.O. BOX 835	LAPORTE TX	77571	USA
10	A.J.ITALIANO	1655 REVERE DR.	BROOKFIELD WI	53005	USA
11	ROG. SCHROEDER	4111 W. 98TH ST	OVERLAND PARK	KS 66207	USA
12	PAUL KARNOW	1752 PAPERMILL	MEADOWBROOK PA	19046	USA
13	ROBT.G.KABCHEF	8600 CONTRERAS	#20 PARAMOUNT	CA 90723	USA
14	PHILLIP WATSON	3 ORMOND COLLEG	PARKVILLE, VIC.	3052	AUSTRALIA

At J.C.

713 471 4843