

factors were directed towards a maximum of inverted performance and when a compromise had to be struck it was allowed to lean towards the inverted factor.

When you think of inverted flying the first thing which comes to mind is the airfoil; you must of course have one which is efficient in both respects. To me there can not be any other choice for this other than a full symmetrical, after all if it is to have equal action in both directions it must be identical on both sides. For the past several years I have been using a well proven and extremely stable symmetrical foil, as a result there was no problem in choosing the foil to be used on the "Crusader"—it would be this one.

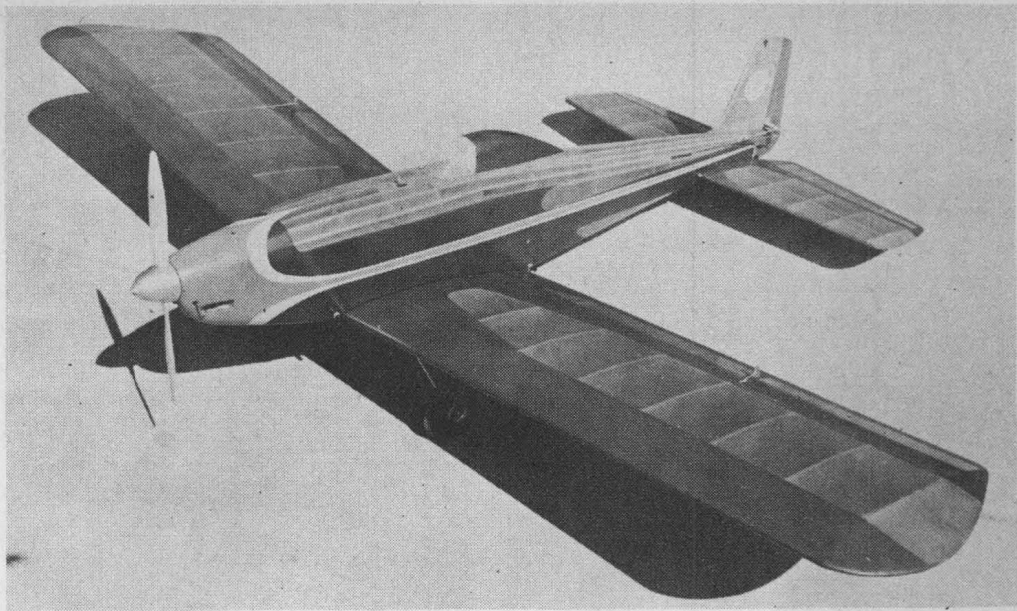
The force setup (angular settings of the wing and stabilizer relative to the line of thrust) used is a bit unusual for a symmetrical type airfoil, however there was a good reason for it. One of the problems with a low wing when inverted is that the tail tends to fly high and thus the effective center of lateral area is high also. This sets up a unstable factor which tends to cause the model to drop off on one wing or another. It would not make too much difference which way the fall-off would occur.

While flying my Live Wires I had noticed that they had extreme stability in this respect while flying inverted. Once on their back they would stay there with no tendency to fall off; a flat bottom airfoil was in use, of course. In analyzing this feature I finally realized that the full down elevator which was required to hold them inverted was also forcing the tail end of the airplane to fly "low". Thus, in effect this attitude was creating a low center of lateral area while inverted giving the added stability which the Live Wire seemed to have.

I felt that it would be extremely desirable if something of this nature could be worked into the low wing design. It could not be duplicated exactly for if it was the symmetrical foil would be lifting when the inverted flat bottom type was not, resulting in an inverted climb instead of tail low level flight.

The symmetrical airfoil lifts well at angles as low as 1 to 2 degrees and with this knowledge in mind the wing was set at a 5 degree positive angle of incidence. The stabilizer was set at a 4 degree positive angle although this is not the least bit critical as tests indicated anything from 3 to 5 would do the job. With these angles upright flight is minus any ballooning tendencies due to the careful balance of stabilizer lift relative to wing lift, much as in the Live Wires.

However, when inverted enough down pressure must be exerted by the elevators so that the wing will be forced to at least a 1 degree angle of attack before



level inverted flight can be obtained. In doing this the elevator action also forced the tail end of the model down somewhat in the same manner as with the Live Wire. Thus, the lowest possible center of lateral area inverted was obtained consistent with the rest of the model's design. In practice this seemed to be one of the more creditable assets which the model had, it did fly inverted with the least tendency to fall off that we had ever observed in an inverted type model.

One of the first questions which I was asked at a flying field was "How much thrust offset do you have in the 'Crusader'?" My usual reply was "none at all" accompanied by a silly grin. Almost every time the result was disbelief as the questioner walked away. This zero thrust was one of the things which I am most proud of simply because I tried hard to achieve it and feel that it is most necessary for the ultimate in all around performance.

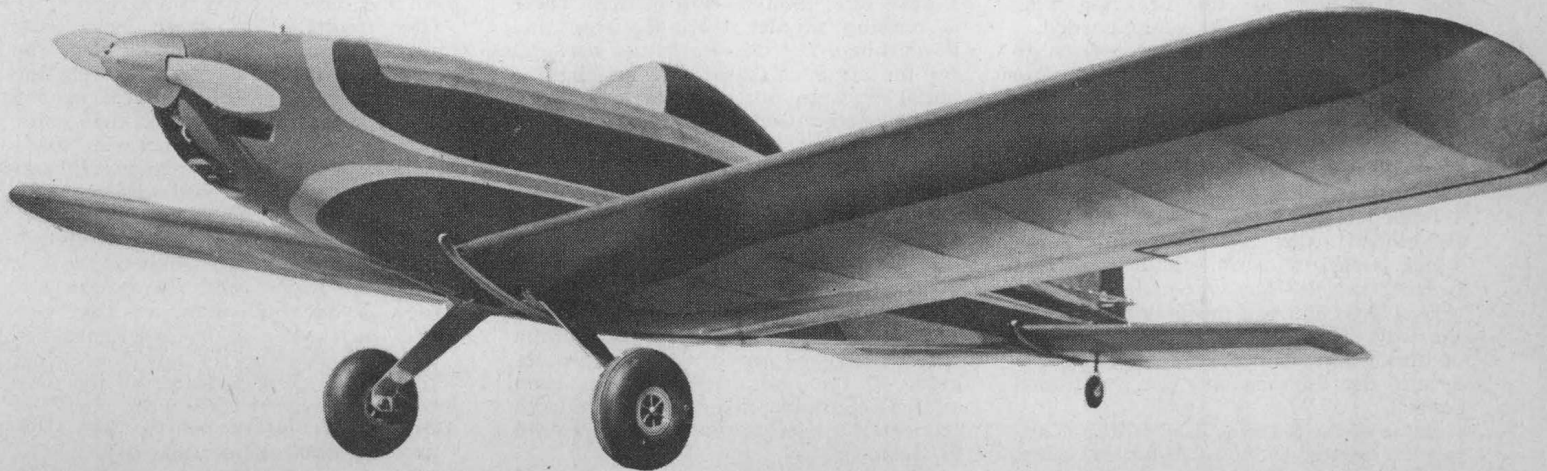
My reasoning was brought home hard to me one night during a "bull session" in Ernie Kratzet's cellar. In discussing inverted flying he stated that side thrust had an opposite effect from what it had upright while in the inverted position, yet the torque which sidethrust was used to compensate was the same. In other words you could expect torque effect and side thrust to team up when inverted. We had some dramatic demonstrations of hanger flying with one of Ernie's models that night; in the end I had to admit that he was right! Since then I have used every effort possible to get rid of all thrust offsets on models intended for inverted flight.

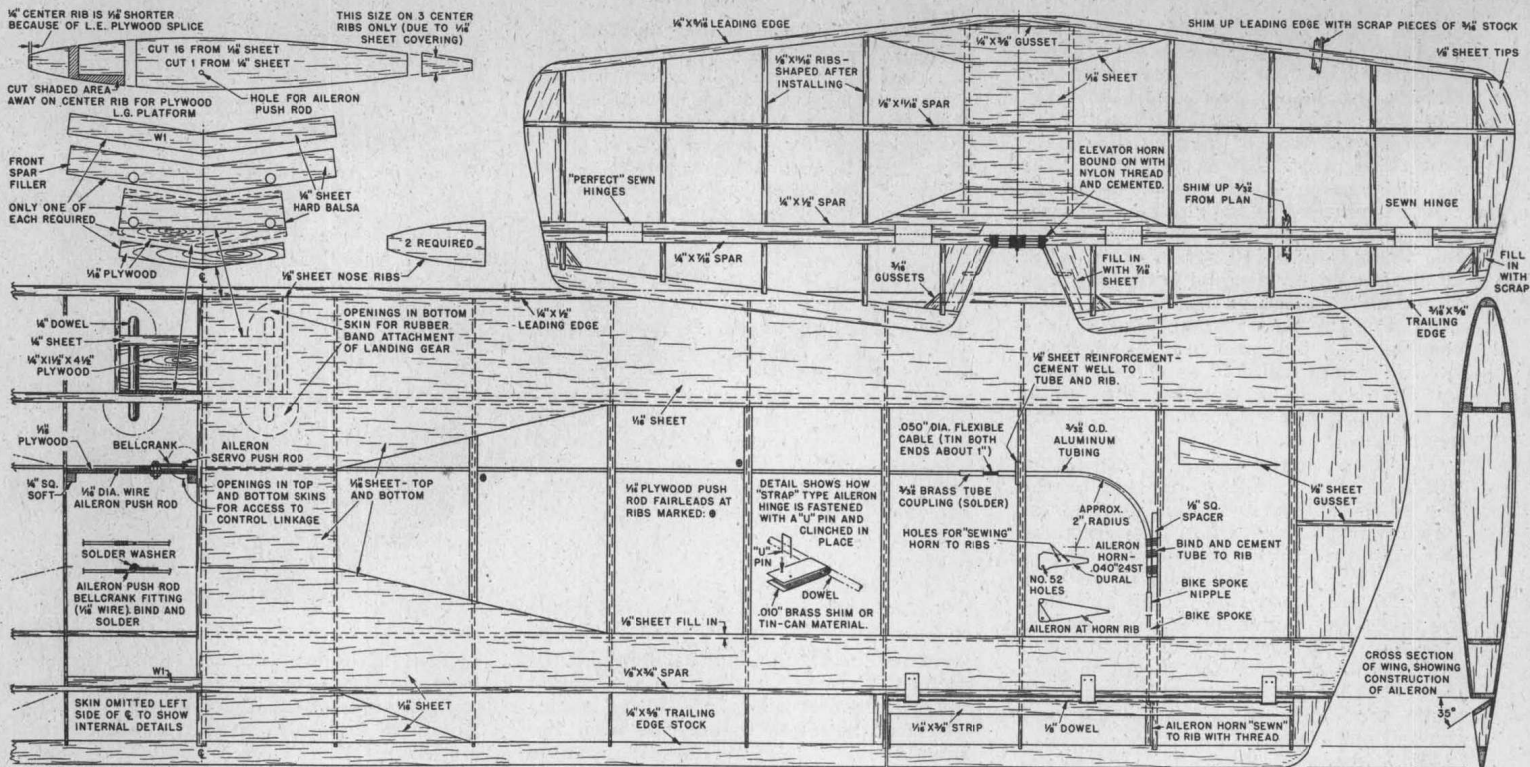
The "Crusader" has no down thrust because of the high thrust line relative to the center of resistance plus the effect obtained from the lifting stabilizer in its Live Wire force setup. The side thrust was eliminated by creating a careful aerodynamic balance of forces pivoting about the C.G. By creating a careful balance here the torque effect was balanced out by all the other factors which could be worked against it. The end result is an arrangement whereby the thrust remains the same no matter in what position the model is flying in.

Another advantage obtained from this neutral thrust comes in ground handling. At taxi speeds torque is much more effective than any counteraction used against it. The natural result is that the model tends to follow the torque at low speeds, side thrust being ineffective the model will tend to turn with the torque and must be compensated for. With no side thrust needed this model tends to go straight under slow speed taxiing conditions.

I have little doubt but what the "Crusader" could be flown with the simplest form of controls, however it would seem to be a waste of good potential to try that. In any case the "Crusader" was flown with the reliable Bramco "Regent 8" for the radio and Model MC type Multi-Servos for the actuators. With this equipment rudder, aileron, elevator, engine, tail wheels and wheel brake controls were used . . . a "full house."

The rudder was used as a basic control at first. The ailerons were used only for maneuvering. Both of these controls used the MCR type servo for its full self-neutralizing features. The elevator and





deBolt's Radio "Crusader"

engine used the MCE type servo. For the MCE engine actuator the two normally-closed relay contacts which usually actuate the neutral circuit were not connected (two wires were omitted) so that with this arrangement the engine servo was completely trimmable giving infinite engine speed control.

The MCE used on the elevator was used as intended, self-neutralizing and yet trimmable about neutral. This trim at neutral allowed the use of the "down-trim" necessary to fly the model inverted with "hands off" on the elevator. The other controls were picked off these in the usual manner now prevailing.

After flying the model for some time trouble was encountered during takeoffs (just after being airborne) and during the last stages of landing approaches a wing would drop and the rudder control just would not lift the wing quickly enough under these circumstances. It was found that a tendency to slow the model down so a short field landing could be made was causing me to fly it too slowly and actually stall out. The simple answer was to switch to ailerons as the basic control so that the low dragging wing could be lifted quickly when needed.

Another answer would have been to adjust the elevator servo so that no "up trim" could get into the elevator, thus the model would always have the flying speed it needed. I think other flyers will encounter my trouble when switching from a high wing or biplane to a low wing. I tended to use a nose-up attitude with the model to slow it down on approaches which is okay with the stability inherent in most models—however with low wings this is N.G. and you must fly them in all the way. The catch is to break yourself of this habit before it creates trouble or else use ailerons only for directional control.

Some of the features used on the "Crusader" proved to have a lot of merit.

Common dural gear saved weight and the work involved of a wire type gear in the wing. Just install the usual hardwood mounting block in the center section of the wing. The dowels are buried in the wing which makes a neater job. The only word of advice necessary: strap the rubber bands on tightly, otherwise the gear could dig into the wing skin should it jump off of its block.

The "Crusader" uses the standard removable R/C unit as in my other models. It is inserted through the wing opening eliminating access hatches. If you are familiar with this box you will remember that the engine servo has been on the right hand side. With the addition of the aileron servo it has been necessary to move the engine servo to the opposite side and install the aileron servo on the right. By doing this the servos need no alteration and can be used in the stock manner.

The aileron system on the "Crusader" was an experiment to give something more simple to install and maintain. The hinge arrangement which has worked very well was a "steal" from one which I have long used in control line. There is nothing simpler than the trap and dowel hinge but be sure to use material for the strap as called for. Too light a metal tends to fatigue after long usage.

This model used a torque rod type of control linkage. As mentioned before the servo for it was mounted in the R/C box. This was done to remove the weight from the wing and to make the box interchangeable between models which does cut the expense of owning more than one model. Removing the weight from the wing can help save it a bit if a "clobber" should occur. The torque rods were 1/16" music wire bent 90 degrees at the ends (one rod for each aileron). Suitable fittings were made to connect the ailerons and servo push rod to them.

This system proved to be "soft" in action and possibly could have suffered from "blow-back" in the air, otherwise it was simple and light to install. The answer I found in one of my Bipes which also used it. I simply arranged the leverage so that the aileron reached its limit stop before the servo reached maximum travel. What happened was that the servo tended to "wind up" the torque rod after the aileron had reached full movement and thus you had a "solid" aileron action in the full control position. Frankly this worked out quite well and no trouble was encountered, however, I felt that the "softness" was a weak point.

The system shown on the plans is brand new and I call it the "flexible push rod." It was not used at all in the original "Crusader" but tests with it in other planes have shown such good results that I felt it best to present it here. This arrangement is simplicity itself. The heart of it is a piece of flexible braided cable (size .050) which runs in a piece of suitably bent aluminum tubing to get around the corner to the aileron's horn. It is a "positive" system with absolutely no softness and no "play" providing the 3 holes required in the various horns are held within tolerance. I feel that it has a great future and is just about as simple as anything can be. For those liking a wing-mounted servo it is a simple matter to install the servo where the bellcrank is shown and operate the push rod directly from the servo.

The results of all these ideas have proven acceptable on the flying field. The model itself proved out well by weighing in on a par with other types; at 5 1/2 lbs it is considerably lighter than most other low wings. This lighter wing loading paid off in better maneuvers and the ability to perform well with an average .35 engine.

After the author got over the "shock" of switching from high wings to the low wing some really good flying was obtained. I do think however that one should have some multi experience before attempting to fly any low wing. You must fly these airplanes all the time and without experience with elevators that can be a bit rugged.

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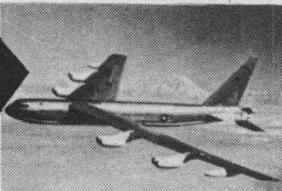
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Inverted flight can be entered from all three ways, half an inside or an outside plus using a half roll. I found the half roll to be more desirable simply as practice for doing the 2 pt roll. Once inverted you adjust for the type of flight desired by trimming the elevator. A small amount of down trim will give level inverted climb and of course full down

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brings it around to upright again!

Once you set the amount of trim desired the model is flown elevator "hands off," simultaneous control is definitely not required. Directional control inverted by rudder is more sluggish than upright so in general ailerons are used instead. They are just as effective as upright plus the fact that they react in the same direction as upright, you don't have to reverse your directional thinking by using them!

This being one of the first really fine inverted machines that the author had flown much time was spent trying out new sorts of maneuvers which this perfected inverted flight offered. We had a lot of fun learning how to do them and of course got our share of applause for accomplishing them the first time.

Of these maneuvers one is Dick Branstner's favorite, an inverted tail spin. Rather spectacular and confusing to watch it is relatively easy to accomplish. When inverted you simply apply full-down elevator until the nose is straight up, then neutralize. When speed has just about completely diminished you apply full-down and full-rudder simultaneously, the result is a tail spin with the model upside down! Another crowd pleaser is to go into a inverted "Cuban 8." This is the regular Cuban 8 entered from the inverted position. It seems funny to see the model in the upright position at the middle of the 8 where ordinarily it would be inverted. The fact that the "Crusader" is a tight-turning airplane makes this one much more pleasing to watch than with some other models.

The show stopper proved to be an inverted "Victory Roll." This one is accomplished from an inverted level flight position, usually near the end of the flight. From this position you apply a bit of up trim (or take out some of the down) which puts the model into a shallow inverted dive. When you have approached the ground about as close as safety permits you apply full down elevator until the nose has come up to about a 45 deg angle and then the elevator is neutralized. Just afterwards you apply full aileron and hold for the number of rolls desired releasing the aileron so that you come out in an inverted position. To recover you trim for level inverted flight as usual. The "topper" is to repeat it going in the opposite direction and recover upright followed by an immediate landing. Shades of the "Blue Angels" . . . we'll catch up to them yet!

In general I feel that the "Crusader" proved out the theories which Swank and I envisioned 4 years ago and that this is only a start towards some mighty fine flying that is yet to come. The answer to it all is of course the marvelous improvements which we have seen in R/C equipment during the intervening years.

I would like to say that I don't believe any low wing model is the best for the beginner in R/C or maybe even for the novice in Multi, but for the multi-flyer with any experience this sort of thing can be it . . . a really "spirited model" with the sky the only limit!

"CRUSADER" SPECIFICATIONS

Wing Span, 66"; Wing Chord, 13"; Wing Area, 858 sq. in.; Airfoil section, NACA 12% full symmetrical; Wing loading, 14.6 oz./sq. ft.; Weight, 5 1/2 lbs; R/C equipment weight, 28 oz; Power, K&B Torp R/C .35; Propeller, Tornado R/C 13-4; Fuel, K&B Super Sonic 1000; Radio, Bramco "Regent 8"; Actuators, Model "MC" Multi-Servos; Fuel tank, dmeco Model C6 oz Positive Flow; Wheels, Veco 3 1/2" R/C Pneumatic; Finish, Red, trimmed with blue & yellow Aero Gloss.

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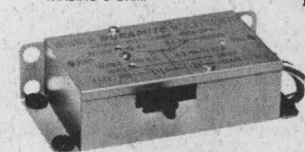
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