BY JIM KIRKLAND

"citron"

What goes into the creation of an outstanding full-house multi-type radio plane? Here the former American champion takes you through all the steps which are necessary to design a winning entry. It's an education in the fine art of R/C.

The Citron design evolved as a result of a two-year test program that involved just about everything common to R/C, from model finishing techniques and color schemes to R/C equipment. Two models that were built during this time flew in a number of contests and had an impressive series of wins. These models still had some unwanted characteristics and the continuing search for the ultimate led to the Citron. While this airplane may not be everything for everyone, it fulfills every performance requirement established by the designer at the outset of the test program. At times the urge to be really different was strong, but performance had been the ultimate aim of the program and was never sacrificed.

I've heard it said that the designer should strive to be different; you've heard the reply that it is difficult and almost impossible to be different! Why? Well, consider that every R/C model that comes off a designer's drawing board is supposed to perform the same functions as other models in its class. The science of aerodynamics and our knowledge of the subject as applied to models, makes it impossible to be very different and still win, or even have a good competition model. New engineering features are constantly showing up, but model performance requirements have remained the same; so has the appearance of most of the top models. Efforts to be different usually result in some performance compromise. This merely taxes the flyer's skill if he is to win. Until the top aerodynamicists discover a way to fly and stunt with something other than wings, fuselages and stabilizers, it is very apt to remain this way!

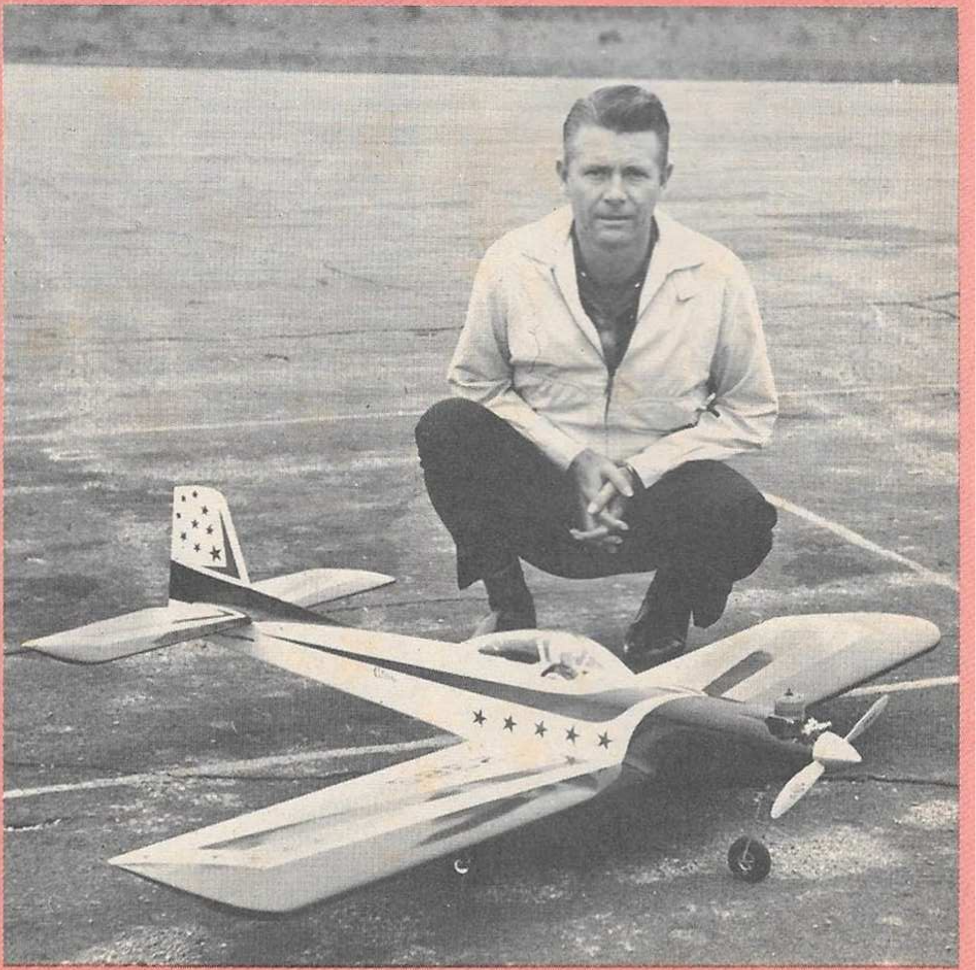
I do not claim to be an aerodynamicist. Most of my model designing is a result of the "cut-and-crash" method. My flying background in the big birds certainly has helped. Anyone who has an avid aviation interest usually knows the basic aerodynamic reasoning behind the various shapes of the many full-size aircraft currently on the aviation scene. Most of the odd-shaped aircraft, and aircraft with unusual design features, were made that way for a specific reason. The aerodynamicist designed aerodynamic functions about the desired performance and operational criteria as established by the demand.

Beauty and eye appeal may, or may not, be apparent. Sometimes some very odd shaped birds kind of *grow* "eye" appeal long after the first test flights. We can look to the sky today and see huge transports and freight haulers, the latest in jet passenger liners, seaplanes, helicopters, massive bombers and sleek jet fighters, tiny racers, biplane stunters and crop dusters, and an endless stream of small personal craft. Each one was designed for a specific function, most are very different in looks, yet very similar in nature.

It is too bad that we cannot design our models by relying exclusively on the wealth of full-scale aerodynamic engineering information that is available today. But, alas, there is that peculiar Reynold's Effect! The smaller an aerodynamic function is, the less it acts like its big brother. As a result of this we must learn through experimentation and the use of a sadly short supply of printed reference material how to make these blankety-blank so-and-so's fly as *we* want them to! It is my opinion that misinterpretation of the Reynolds Effect, together with misuse of full-scale aerodynamics in model application, has probably caused more hard knocks and headaches in R/C model design circles than anything else.

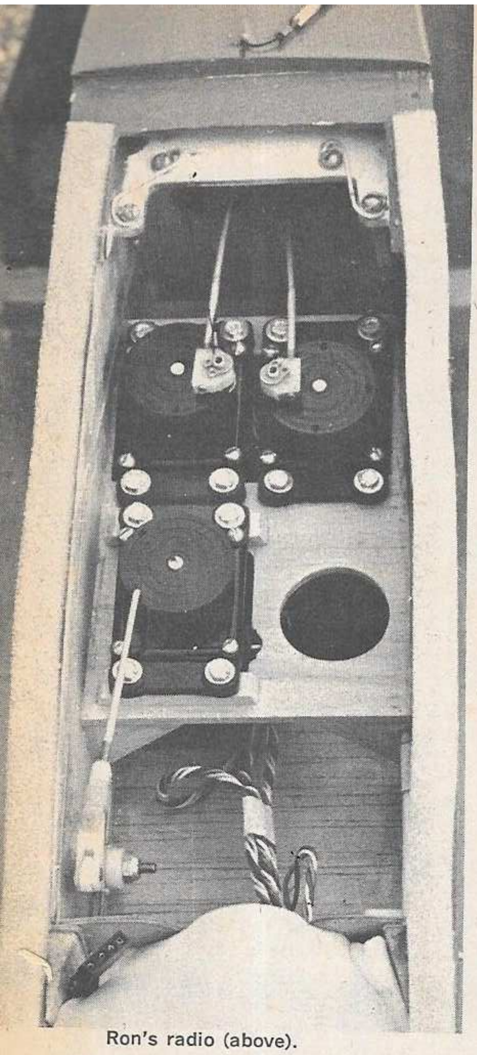
The Citron test program proved to be very interesting and informative despite its "cut-and-crash" nature. The first step was to establish design parameters. At the outset it was decided to shoot for the very tops in performance first. Second was to be reasonably good looks, and, finally, it must be easy to build. Performance proved the most difficult to attain. This feature can only be estimated in the design stage and requires time to evaluate and catalog properly. Of course, the worst thing was the amount of work involved! Except for the stimulating nature of some of the returns, I surely would have felt short-changed in this part of the program!

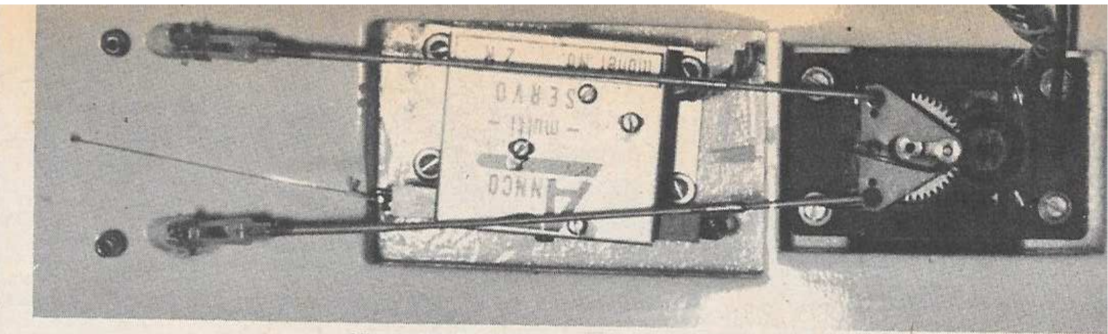
The successful Beachcomber was used as the basis of our series of experiments. Each successive model that was built retained the features that worked and substituted ideas for undesirable performance characteristics. Nose and tail moments were varied; aspect ratios were varied, airfoils and flying surface planforms were varied, hinge line operational modes were varied, control surface shapes were varied, lateral area distribution was varied, CG experiments were made with all configurations, thrust line locations were varied. It was inevitable that as the Citron evolved, it would strongly resemble the Beachcomber. By now you must certainly have realized that all so-called "designers" have a slightly



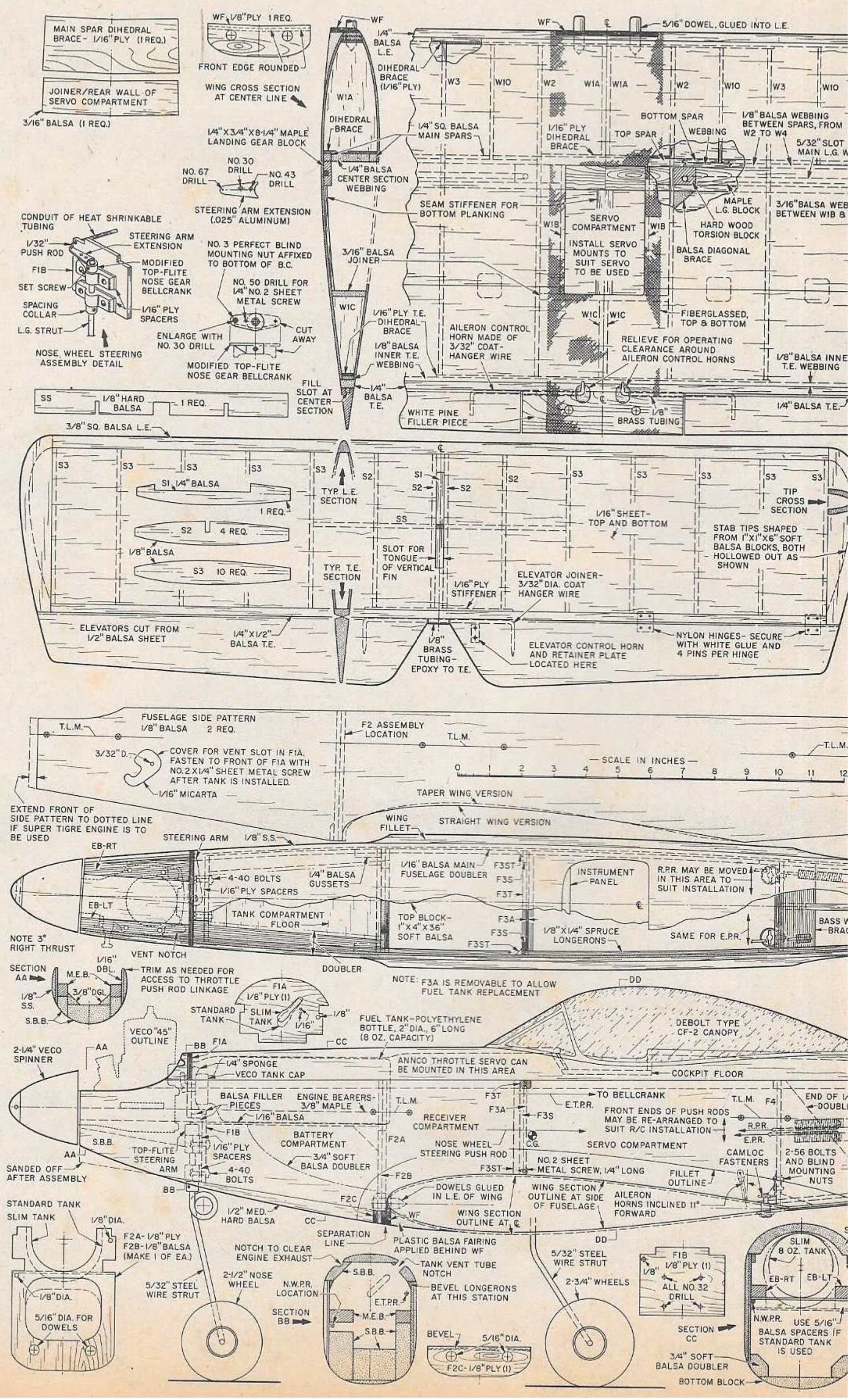
Author/designer Jim Kirkland, former National champion, with constant-chord Citron.

Ron Chidgey and his taper-wing Citron. Jim placed 1st, Ron was 3rd, at King Orange meet.

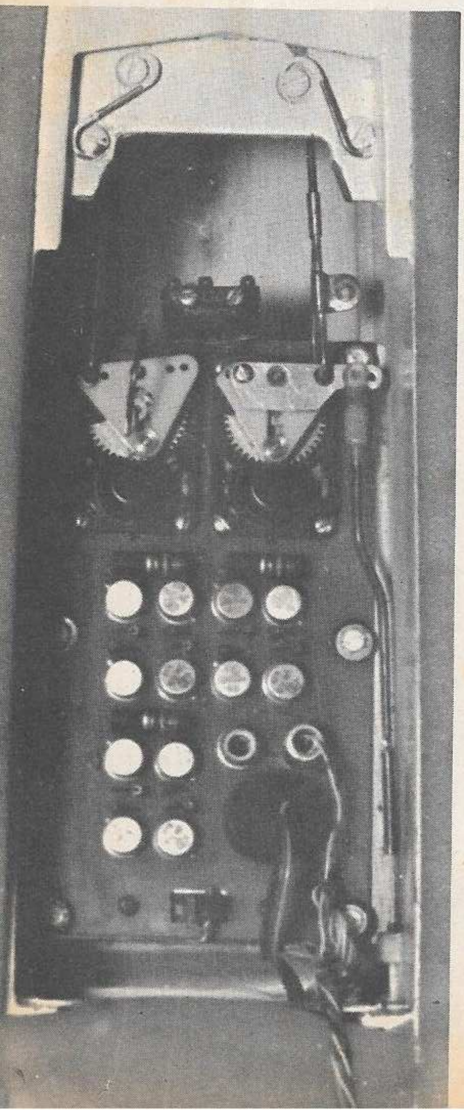


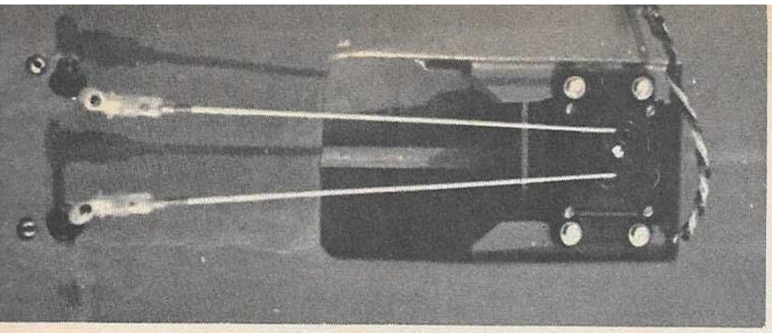


Aileron/brake servo in constant-chord straight-wing.



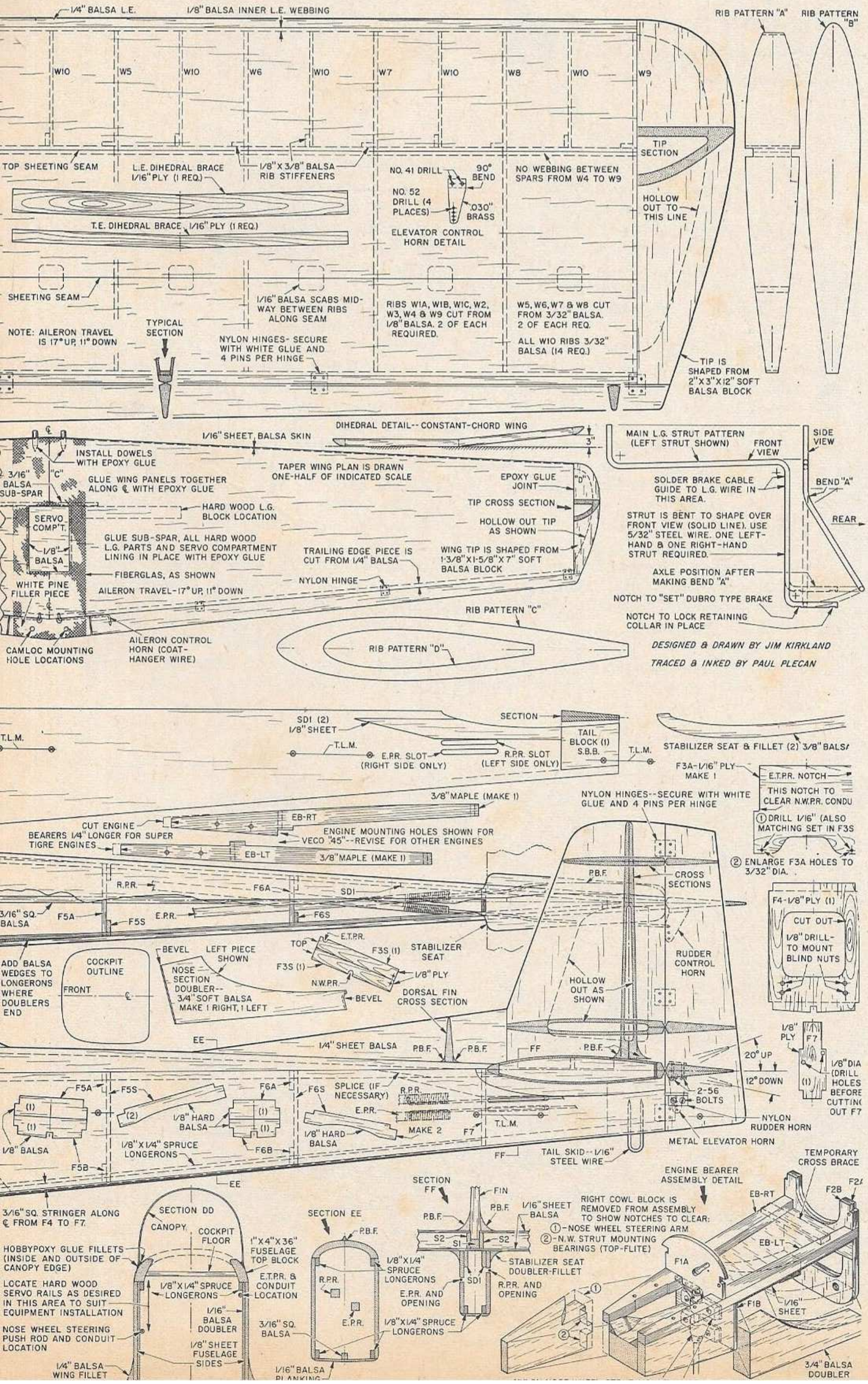
Ron's radio (above).
Jim's fuselage (below).





Quadruplex installation is shown in Kirkland constant-chord Citron. Micro switch behind two servos operates brake servo when elevator servo is in full down position and throttle is 2/3 or more retarded. Dzus springs at rear hold wing; rcvr in foam up front. Extension on rudder servo is for more nose wheel throw. Orbit propo installation is seen in Ron's taper-wing Citron. Bellcrank changes level of throttle pushrod to servo disc level. Ron makes functional nylon parts himself. Plenty of room for 10-channel reed systems. Nose wheel steering is by fork off rudder pushrod in rear of fuselage. In the straight-wing brake servo is independent of the proportional system. Armalite wing core. Orbit aileron servo is seen in the taper-wing which is built with foam core.

Orbit aileron servo in taper-wing.



one-track mind!

The first series of experiments were with different nose and tail moments percentages. A longer nose would increase stability due to the gyroscopic effect of the running engine. Too long a nose moment and CG location would become a problem. The nose moment selected gives good stability and will accommodate the medium and large engines with very little difficulty in achieving the proper CG location. The tail moment selected, coupled with the aspect ratio and area of the stabilizing and control surfaces, gives the best stability and smoothest control possible with the least amount of drag. This combination of moments and surfaces makes the design equally at home with reeds or proportional as the control system.

Airfoils were also a major part of the first series of experiments. The first necessity was to decide whether to use a thick or thin airfoil, then airfoil shapes had to be investigated for each type section. Airfoils of 14 to 16% thickness were classified as thin and demonstrated a very sharp transition from controlled flight to a fully stalled condition. Airfoils of 17 to 21% thickness were classified as thick and demonstrated an ill-defined transition from controlled flight to a fully stalled condition. The thick airfoils stalled at a slower speed, but the degree of control began to fade before the stall occurred. Since the degree of control is much more important under adverse wind conditions, the thinner sections were favored for the design.

The next step was to develop a thin airfoil, plan shape and wing loading that would provide the best performance features possible. My good friend and modelling associate, Ron Chidgey, undertook the tapered planform development and I stuck largely with the constant-chord wing. This is still the basic RAF 30 airfoil I have used for 3 years with good success in wind, but of a different size and aspect ratio than I had been using. This increased the wing's efficiency and at the same time increased the wing loading. The tapered wing planform that Ron designed is unusual in that the tips are 17% sections while the root is 15%. Because of what is suspected to be an increase in the Rey-

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nold's Effect at the tips, most models with a tapered wing seem to have a tendency to fall off on one wing or the other as the model nears a stall in gusty conditions. By increasing the thickness percentage of the tip, Ron has lowered the stall speed of the tips and overcome this annoying characteristic to a very acceptable degree.

An interesting feature that can be noted by studying the loading figure is that as the wing area decreases the weight of the model becomes more and more critical in determining wing loading. Thus the larger the wing area, the less critical the addition of 3 to 4-oz of weight would be to the model. By the same token, to maintain a 21 to 23-oz wing loading for a model with an exceptionally large wing area would require a very heavy model.

I like to refer to a model's weight in terms of the model's inherent inertia factor rather than as a light or heavy model. In my opinion this inertia factor is as important in determining how the model will react in gusty wind conditions as is the wing loading factor. While it is true that both factors are tied irrevocably together, it is possible to change the wing area and the wing loading without materially affecting the inertia factor. It is also possible to change the inertia factor and maintain the same wing loading by changing the weight of the model and the wing area. Most every R/C'er has witnessed the effects of the inertia factor if he has ever watched a small ½ A or ¼ A R/C model fly in gusty wind conditions. When flown under similar rough air conditions, a small model with a 22-oz wing loading will bounce about more than will a large model with a 22-oz wing loading. In some measure this is apparently due to the increase in the inertia factor of the larger and heavier model.

The inertia factor is also very important in determining the amount of engine power required to fly a particular model through some maneuvers. Take the vertical eight, or a big loop, for instance. Discounting aerodynamic drag, the amount of inertia present will determine how much power will be required to pull the model through these demanding maneuvers. If the inertia factor is too high for a given model, then the amount of power required to do these maneuvers will be considerably in excess of that required to perform the easier maneuvers.

The final bonus to be realized from a model with the proper inertia factor is smooth maneuvering. Take a wad of paper, a baseball and a chunk of lead, all equal in dimensions. Throw the paper and, despite the power of the throw, it is going to be erratic in flight. Throw the baseball and flight path will be smooth, the distance good, for the power exerted in the throw. Now throw the lead and, while the flight path is good, the distance is sure going to suffer despite the effort exerted!

The Citron design considered these many variables and the 6¼ to 6¾-lb design weight gives a wing loading of from 21 to 22-oz per square foot of wing area.