The radio-controlled soarer in full flight

How to Control Your Plane By Radio

How a Radio Amateur and a Model Plane Expert Have Created One of the Most Practical Radio-controlled Planes That Has Ever Flown

By CLINTON B. DE SOTO

RADIO control of model aircraft has long been a vision of great delight to experimentally inclined builders. Its accomplishment in a thoroughly practical and reliable manner has not so far been realized, however. Despite the showing in the number of radio-controlled entries at Detroit this summer, it would be a bold prophet indeed who would predict that in any one of these models lay the end of the search for practical ways and means.

One noteworthy angle on these attempts has been that, for the most part, they represented the work of gas model experts turned radio experimenters. Now a new line of attack has appeared from the opposite quarter. The radio experts of the American Radio Relay League, the national organization of radio amateurs, have been conducting experimental research into the problem at the League's West Hartford, Conn., headquarters during the past summer.

As a matter of fact, this interest on the part of the radio fraternity is especially fitting, since it is only with their cooperation that model builders as a lot can do much with radio control. The operation of any sort of radio transmitting equipment—equally as much that for controlling model aircraft as that for sending voice or code—requires the possession of federal operator and station licenses. And only amateur radio operators, with the exception of those few individuals possessing commercial experimental licenses, are authorized to carry on this sort of work.

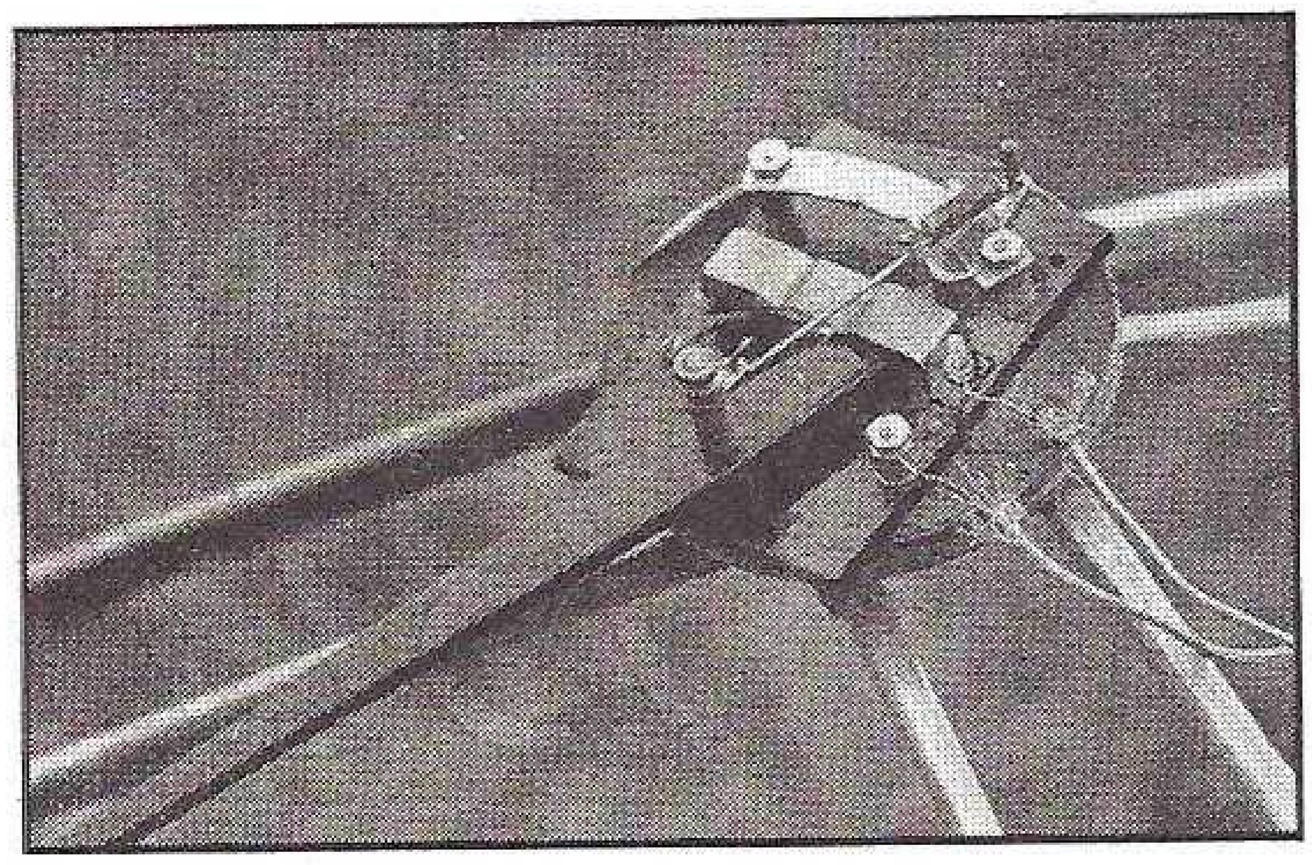
The progress that has been made by the A.R.R.L. gang is such that it seems to hold the basis for widespread general investigation of this field in the near future—with building and designing in the coming winter months and actual flying next spring and summer.

To tell the story chronologically, it should be stated that Ross A. Hull, noted ultra-short-wave radio authority and associate editor of "QST" and others of his associates in the League have long experienced a corollary interest in model aircraft. Indeed, Hull is one of the progenitors of modern model building activity, having brought the technique from Australia and introduced it to Hartford and surrounding areas in 1927 through a series of newspaper articles. He has built numerous models and has a sufficient knowledge of aerodynamic theory to qualify him for the present investigation.

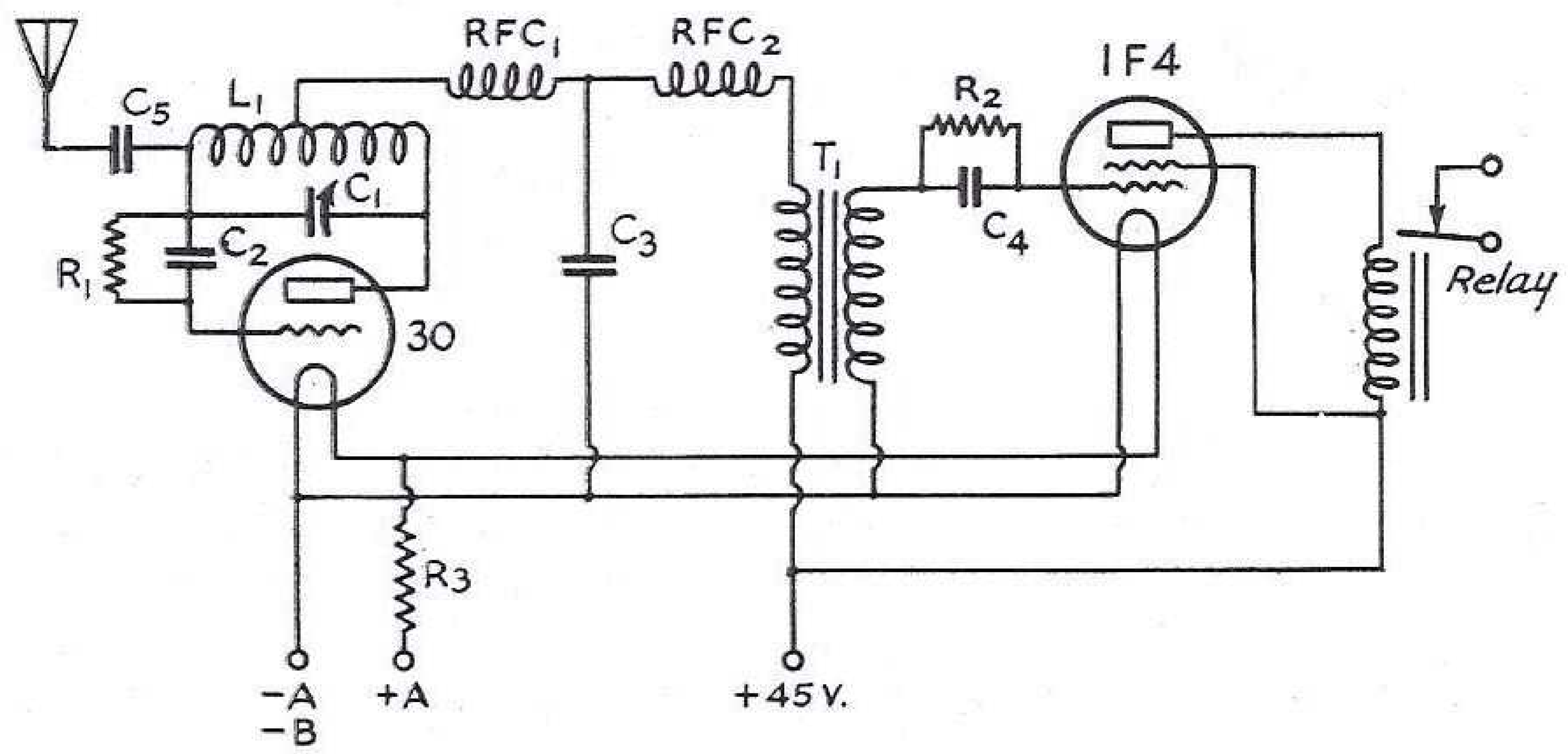
Through the early months of this summer there developed a growing interest in radio control among this group. Tentative control systems were laid out on paper and discarded, the disadvantages of undue weight of complexity being too great. Finally, in late June, the idea for the present system germinated, and work went ahead in earnest. A 2-cylinder Fergusson engine was secured and plans for a 10-ft. gas job laid out. But then, as it usually does, fate stepped in.

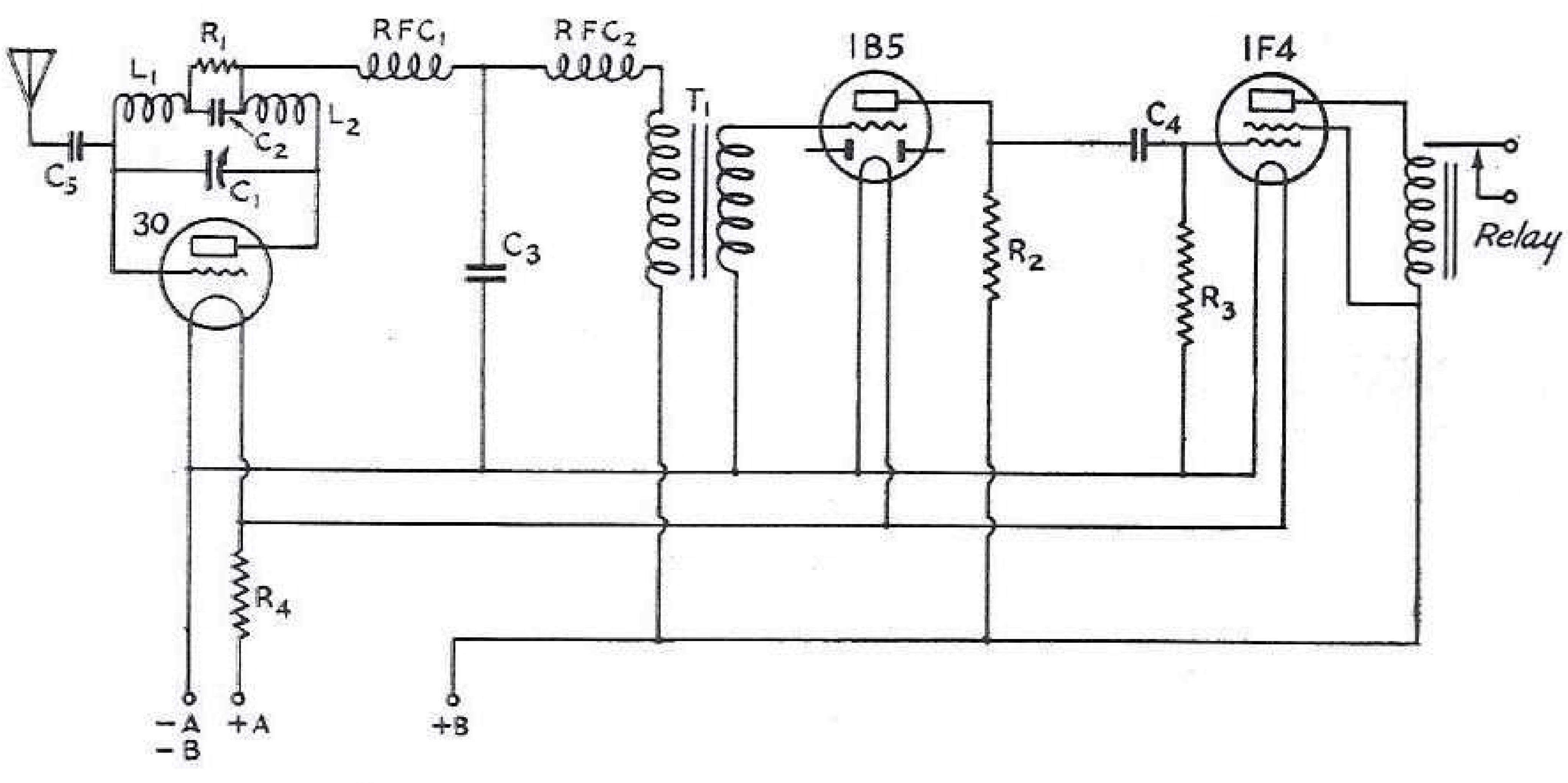
In early July Hull and R. B. Bourne, another old-time model builder, made a trip to the National Soaring Meet then being held at Elmira. (A regular practice with Hull, who had first equipped soaring planes with radio for communication back in 1932.) There they found, of all things, a radio-controlled model sailplane, the "Hi-Hat," built by Carl W. Thompson, Jr., of Wilmington, and equipped with radio gear by H. M. Plummer, owner of amateur station W3DIA.

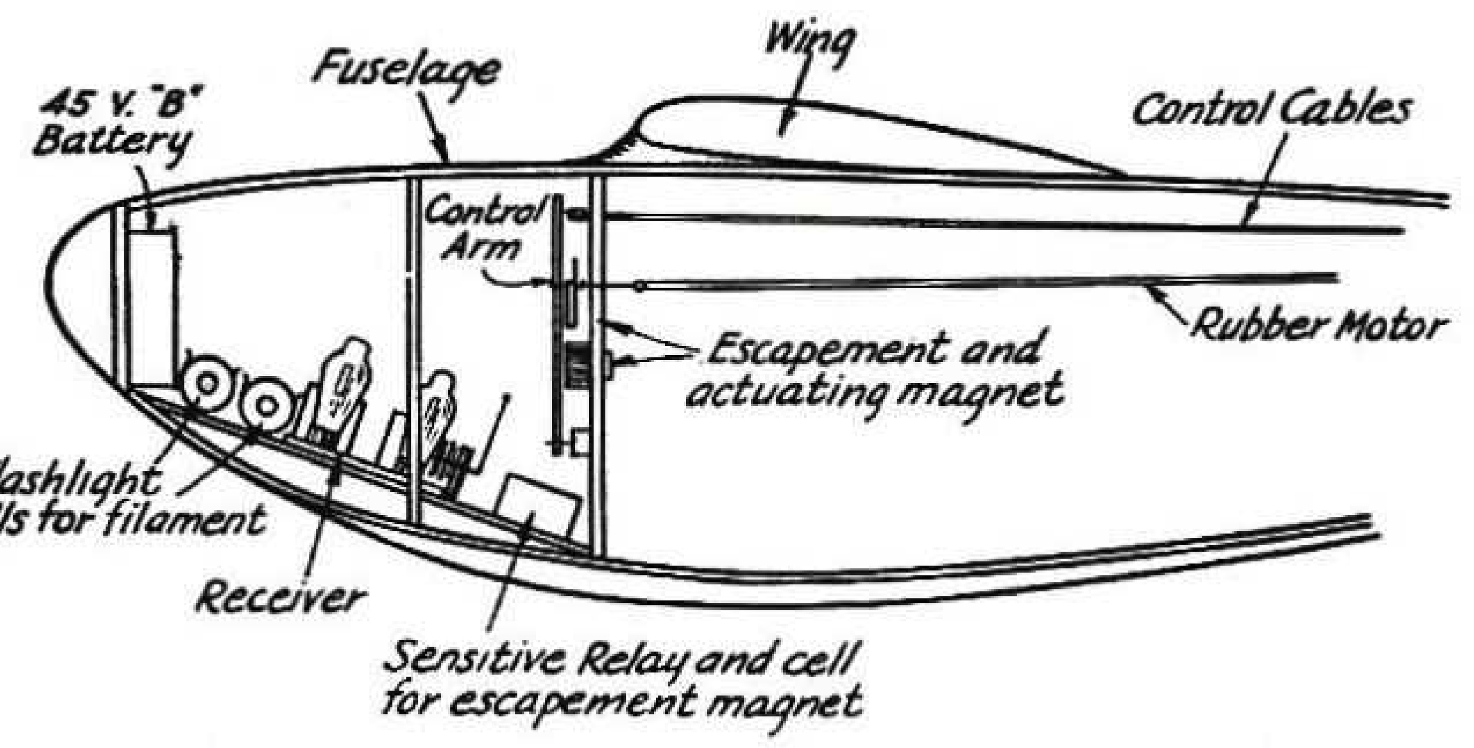
This ship was arranged to fly ordinarily with right rudder and the armature from a telegraph sounder served to give an alternative left



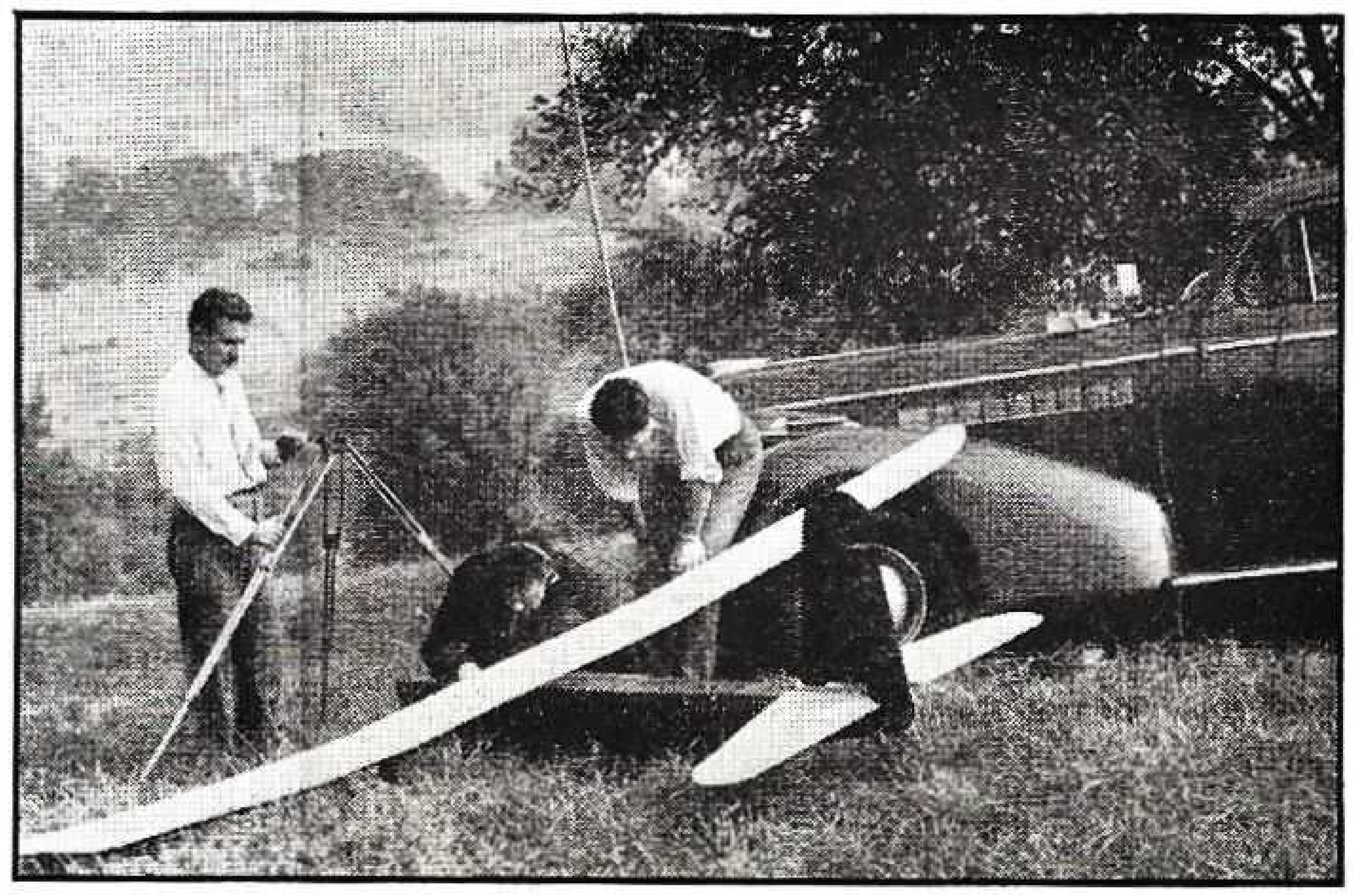
The "rudder stick" by means of which the pilot controls the plane from the ground







A diagram of the control mechanism installed in the fuselage of the model



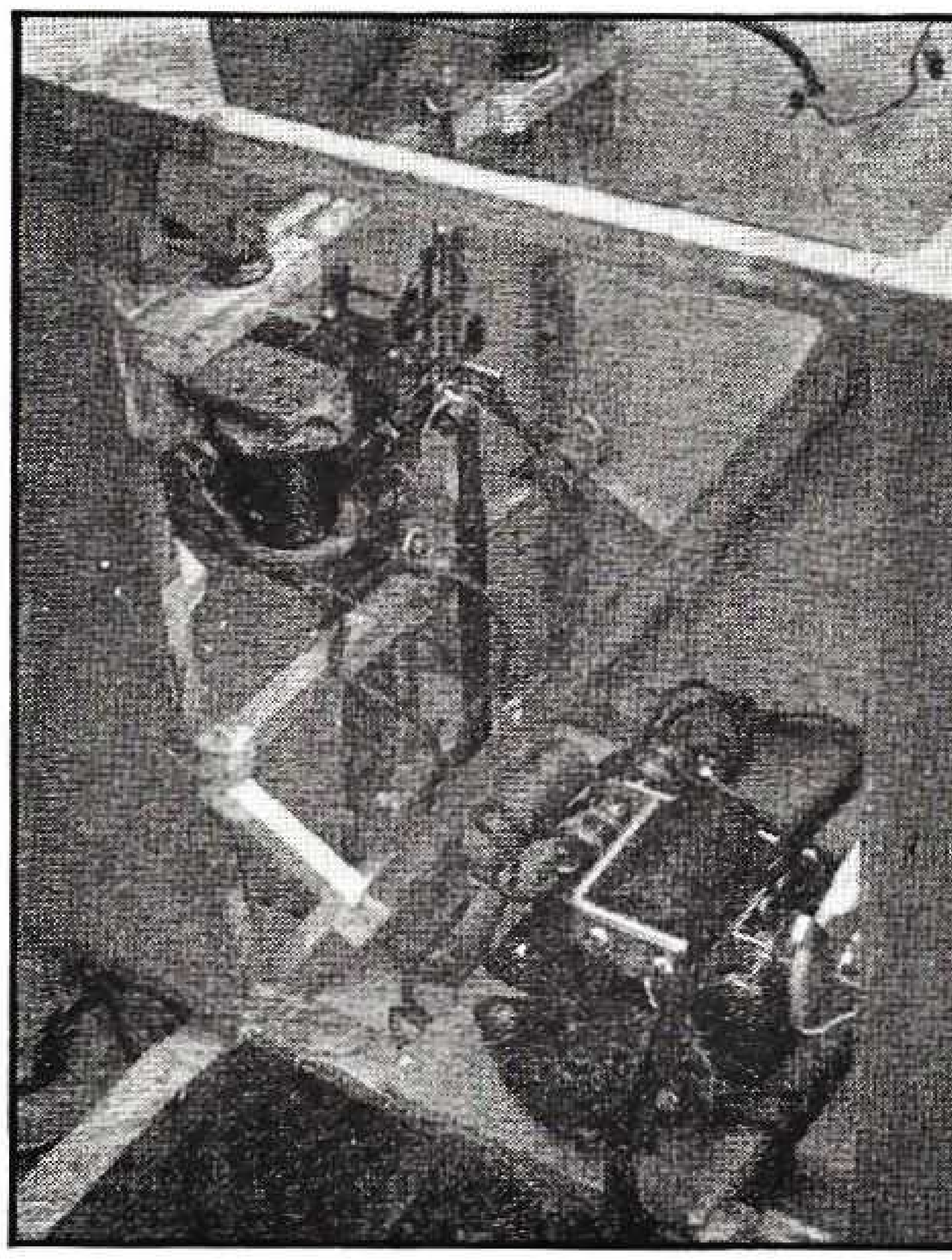
Preparing the soarer and radio control equipment for a flight at West Hartford, Conn.

rudder. The ship made several brief hops before an untimely crack-up ended the experiment. Undaunted, Hull, who visualized how his own system might have functioned under similar circumstances, acquired the remains and brought them back to West Hartford.

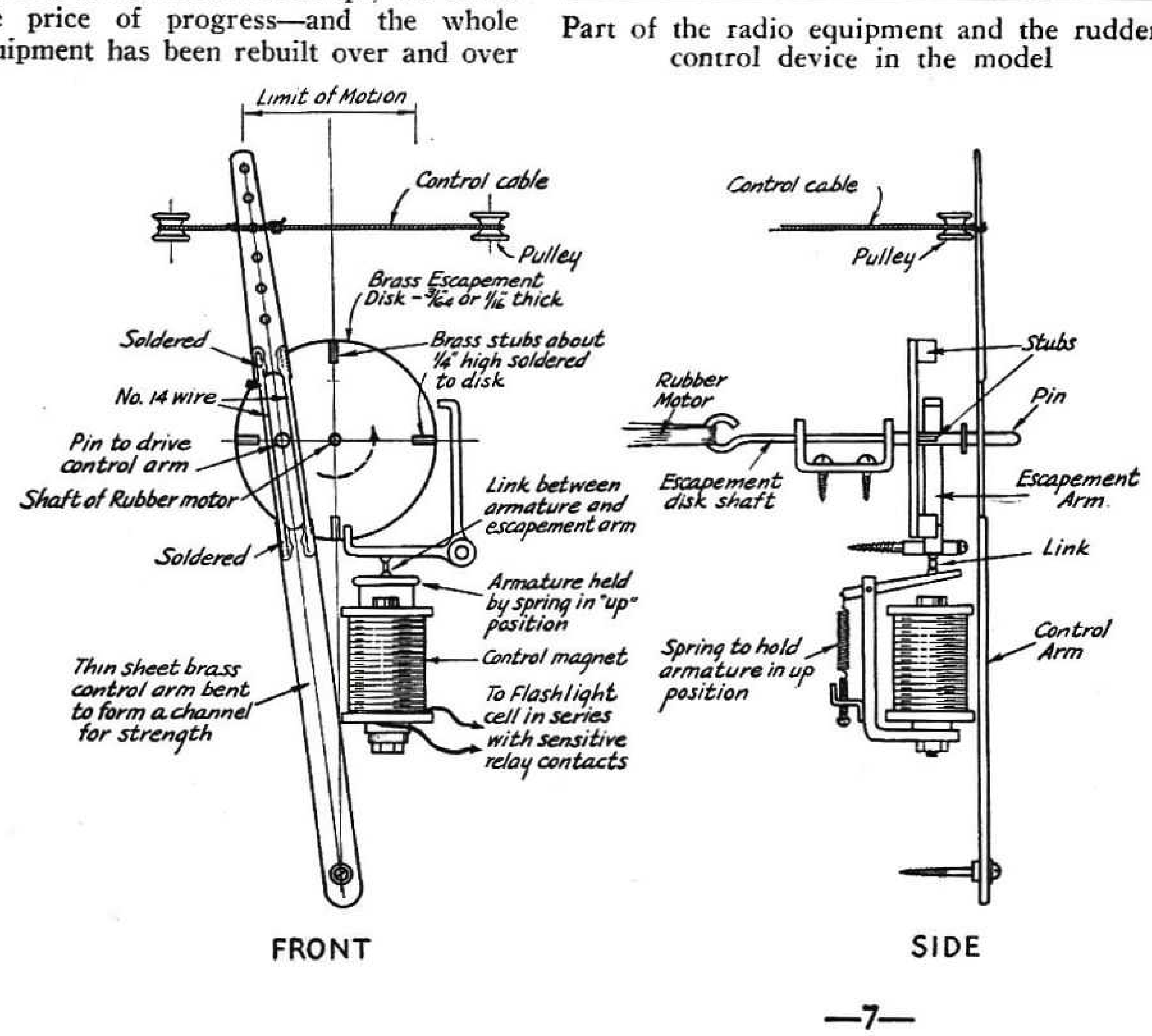
In the weeks that followed he and his group did little but eat, sleep, talk and build radio-controlled model aircraft. Success was not immediate, but it did come—if the present system, crude as it is in comparison with the ultimate goal, can be called success.

The first job was to rebuild the ship. Although not in the high-performance category, it has proved itself a rugged and willing worker. Of 13-ft. span, the wing is in three sections, the tips being from an old gas model of Thompson's augmented by a flat center panel. The rib section is an original, being similar to a Clark "Y" but having the maximum depth near the 40% point. The fuselage is square in section, except for the bottom, which contains a strong "keel" to resist the heavy landing force of a 10-lb. ship. All surfaces are nainsook covered and heavily doped.

Since its first flight with the new radio control equipment in July, this ship has made more than a hundred flights—not without some fifteen crack-ups, but that's the price of progress—and the whole equipment has been rebuilt over and over until there's practically nothing left of the original. The performance of the ship has been demonstrated to many visiting model aviation and radio enthusiasts, including officials of the Soaring Society of America.



Part of the radio equipment and the rudder control device in the model



The times the radio control has failed to function can be counted on the fingers of one hand. Some of the flights have had a duration of several minutes, most of them less; the relatively low gliding angle of the ship and the imperfections of the gliding site have made any real duration almost impossible.

So much for the why and where. Now for the details of the control system that made these results possible.

Like with most good things, simplicity is its keynote. A preliminary examination of the problem made it evident that the traditional control methods—automatic selector switches, electromagnets or electric motors to actuate the controls, and all the rest of it—were impracticable for small aircraft because of their inherent complexity and weight and also because of the additional weight in the heavy batteries required to power these devices.

Even more compelling than these considerations was the thought of all the things that could go wrong with a complicated selector arrangement while in flight, and the havoc that would result through failure. So all these ideas were discarded and a start made at the bottom.

The first step was to choose a rubber band motor to provide the power for control, in lieu of any electrically-operated device. Any model builder knows that a rubber motor will provide more energy per ounce of weight than any other comparable source of energy. A multi-strand motor four or five feet long could be charged with at least a thousand turns, enough for several thousand control motions.

The next step was the construction of a device to trigger off this power and transfer it to the control surfaces at the operator's wish. Again, simplicity was sought. The simplest arrangement that could be found was a plain four-position escapement, rotated by the rubber motor, released one notch at a time by a small electromagnet operated by the radio receiver. This escapement, in turn, moved a control arm which served as a rudder bar.

The whole arrangement is shown in the sketch. Each time the electromagnet receives a pulse from the receiver, the armature depresses, releasing the escapement one notch. As the escapement disc rotates the sliding pin through the rudder bar moves that bar from neutral to the next rudder position. The whole action is simple and positive.

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A Prize Winning Catapult Glider

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fuselage consists of a sheet of very hard ⅛" balsa in the center with another sheet of ⅛" medium-hard cemented well on either side. The correct cross-sections for the different stations are illustrated on the plans. The launching hook is bent from .040 music wire. Note that it curves around to the top to protect the nose. It is bound in place with thread and the joint covered with a cement skin. Three coats of glider polish are applied to the whole ship which is finished down with very fine sandpaper.

The model is adjusted to circle to the left, thus when it is caused to bank right on the launch it will describe a figure "S" curve which is advantageous in gaining altitude.

Upon the launch the speed is tremendous, but it is surprising to note how the model slows down to the soaring speed. Be sure to adjust the model via a hand launch before trying a catapult launch. It is best to fly the model in an open place free of a great many spectators, since it is quite dangerous should it be out of adjustment at its high speed.

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It should be said here that the present radio control system utilizes rudder control alone. No attempt is made to manipulate elevator or ailerons—although that could readily be done by the addition of auxiliary channels. It was Hull's original conviction—amply supported by later trials—that any ship with sufficient inherent stability would be able to take care of itself longitudinally. If there were lift, it would climb. If there were no lift it would descend, at its normal gliding angle. The sole requirement, then, would be directional control, to keep the ship into the wind, away from trees, etc.

Perhaps this point should be amplified further. The principle applies to gas models as well as soaring planes. All that is required is sufficient inherent stability to keep the ship flying in normal attitudes. Then when the power is on it will climb. When the power is off it will descend—not in a dive, but in a smooth glide to a landing. If it does not perform like this there is a basic defect in the design or the adjustment is incorrect. Witness the performance of the original KG model, as an example—four years old, and still making perfect flights without once a serious crack-up.

So much for the argument concerning directional vs. other means of control. There's one other point to get cleared up. That concerns the necessity for going through one control position to get to the other. Obviously, the escapement in this control system rotates in only one direction. Suppose the rudder is in neutral. A single impulse from the receiver moves the rudder into left position. The next pulse puts it in neutral again. Then comes right rudder, and again neutral. But then if some more right rudder is wanted it is necessary to go through left rudder first before right can be reached.

This seems like a real weakness, but in practice it has been found of little consequence. The whole operation can be performed so rapidly that the rudder seems merely to wiggle and the ship responds, if at all, with nothing more than a slight flicker. Considering that the ship flies at perhaps 25 miles per hour, and the rudder has sufficient area to exercise sharp control, this seems a thorough test. Even with sensitive gas models no difficulty is anticipated on this score.

And now back to the control mechanism. The next step in the chain is the receiver itself. Oddly enough, considering that the work was being done by one of the world's foremost authorities in this particular kind of radio work, more difficulty was experienced here than with any other part of the system.

The trouble was, of course, that very tiny batteries and low potentials were necessary in the power supply in order to keep the weight down and it became difficult to get any appreciable current change. The use of a sensitive intermediate relay operating on a current of a milliampere or two which actuated the control electromagnet was, of course, essential, but even this plate current change was found extremely hard to get with a plate voltage of 45.

Passing over the numerous experimental layouts which were tried and rejected, the circuit of the receiver now in use is shown in Fig. 2. It has several advantages over its predecessors, one being that it operates from the r.f. carrier and not from superimposed modulation. The latter system is easier to make function but complicates the transmitting equipment and requires continuous transmitter operation, a disadvantage with mobile transmitter units operated in a car.

The detector tube is a Type 30 in a super regenerative circuit, operating on 56 mc. A 1B5, chosen because of its high amplification factor, serves as intermediate audio amplifier, the diodes being left floating. The output tube is a 1F4, the only tube which will provide sufficient plate current change to operate the relay. In operation, the supering rush from the detector, rectified, serves to bias the 1F4 until its plate current is about 0.6 ma. A transmitted pulse of carrier cuts off this rush noise and the plate current rises to about 2 ma. This change is ample to close the relay provided the tension spring is carefully adjusted.

That's just about all there is to it. No antenna is used; a 30-watt transmitter a mile away will actuate the relay without one. A short length of wire taped to the fuselage can be used if desired.

The transmitter is a simple push-pull affair using a pair of 45's (filaments in series on 6 volts) operated in a car from a 300-volt 100-ma. Mallory Vibropack, with a collapsible half-wave horizontal doublet antenna. A 6A6 rig with even lower power would be quite satisfactory.

With the control system functioning and everything in order, the next problem that arises is transmitting the wishes of the pilot in a simple and unconfusing fashion. The first attempts utilized an ordinary telegraph key—a single dot for left, three for right, and so on. This led to hopeless confusion—and several inadvertent crack-ups! It was simply impossible to remember what came next.

Then a control wheel equipped with a ratchet allowing it to turn in only one direction, with four contacts at the 90° points and a handle to show direction, was built. This was much more successful. Another method—and the current favorite—is the "rudder stick" shown in one of the photographs.

The necessity for having a direct-acting control device that does not lead to confusion will be evident during the first attempt at control while in flight. Flying this ship is no child's play. It is simple enough when the ship is near by and the rudder movements can be seen. But steering it past a tree in an up-wind turn a quarter of a mile away—well, that's a different matter. Look out the window and visualize steering a car five blocks away traveling around a corner at 25 miles an hour by radio control and you'll see what I mean.

But it can be done, and when you have mastered the technique you'll have entered one of the most thrilling and fascinating games there is. They say that soaring is the "King of Sports," and even power flying is no bore. Then think of the inimitable thrill of seeing your own ship dip and turn off up in the blue in instant, precise response to your slightest whim!

A few constructional details:

The radio-control equipment should be built on a small plywood base firmly screwed into the fuselage framework. "Shockproof" spring mountings have proved uniformly disastrous to tubes and equipment, the "plunge" of the gear in such a mounting when landing being much greater than the landing shock in the fuselage itself.

The batteries used in the present equipment are, for "B" voltage, the Burgess W30BPX or Eveready X203, weighing about 10 oz. each, and for filament and electromagnet solenoid supplies, ordinary 1-inch flashlight cells. The latter were chosen not only for lightness but because of their inexpensiveness and general availability.

Some difficulty has been experienced with microphonic tubes, the shock of the escapement releasing proving sufficient to trigger off another pulse of plate current and moving the rudder an additional step. The only cure for this to date has been to select tubes for non-microphonic qualities. Possibly an almost rigid spring suspension mounting for the tube would be an answer.

The choice of control wires presented some early difficulty. Cords, even of heavy fishline, were too prone to stretch, yet wire could not be made to travel smoothly over the pulleys. The answer lay in using a few inches of cord right at the rudder bar end, where the control cable traversed the pulleys, splicing into lengths of wire for the long run back to the rudder.

Originally the rubber control motor was wound with a winder through a hole in the rear of the fuselage. Now a small crank has been attached to the escapement. The motor is ordinarily left wound with the remaining turns after a flight—not so good for the rubber, but it's easier to replace a motor once a month than to wind and unwind it every day.

The number of strands in the rubber motor will, of course, depend on the force required to move the rudder. Six strands were used in the present model, providing complete reliability.

And now, a final warning:

As has been said above, it is a federal offense to operate any form of radio transmitting equipment without operator and station licenses. The maximum penalty for such unlicensed operation is two years in a federal penitentiary or a fine of $10,000 —so don't take any chances! Get a licensed ham to work with you. He'll be glad to co-operate, and he'll be able to help you out with the purely radio problems that might otherwise stump you completely. And you'll both get a whale of a lot of fun out of the sport.

For sport is just what it is. "Radio-control of aircraft"—if not the "King," then the "Crown Prince of Sport!"