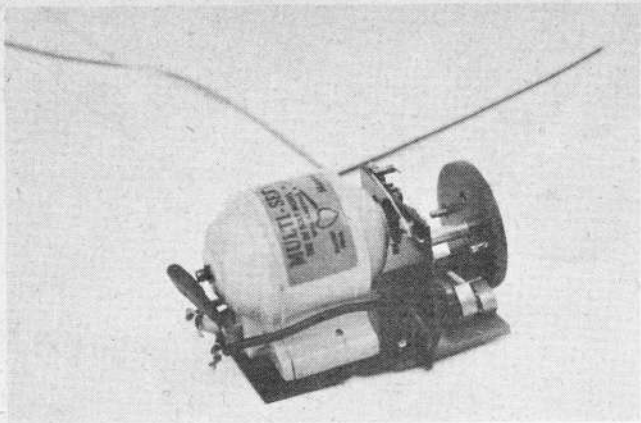
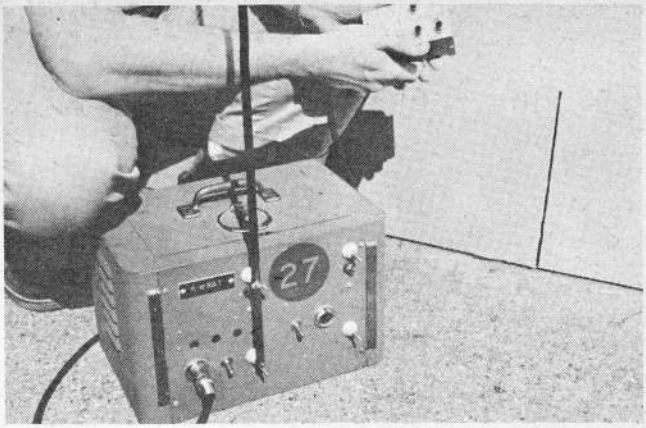


(Photo #1) Model 2PN Multi-Servo showing modification to neutral contact, which is the one positioned closest to servo motor. Diagram No. 2 shows how contact was altered.



Two channel control box (photo #2). Button at left hand is for elevator control. Button by right thumb operates rudder and engine. Upper (3rd) button works both elevator-rudder.

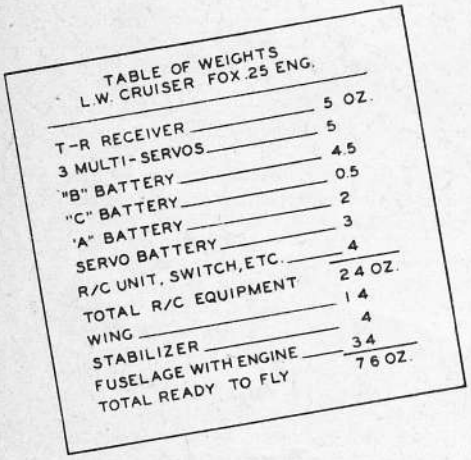


TABLE OF WEIGHTS
L.W. CRUISER FOX .25 ENG.

T-R RECEIVER	5 OZ.
3 MULTI-SERVOS	5
"B" BATTERY	4.5
"C" BATTERY	0.5
"A" BATTERY	2
SERVO BATTERY	3
R/C UNIT, SWITCH, ETC.	4
TOTAL R/C EQUIPMENT	24 OZ.
WING	14
STABILIZER	4
FUSELAGE WITH ENGINE	34
TOTAL READY TO FLY	76 OZ.

Automatic Multi-Control R/C Flying

Some very practical suggestions for achieving sensational results from standard equipment in conjunction with 2 channel tuned relay receiver

By HAROLD deBOLT

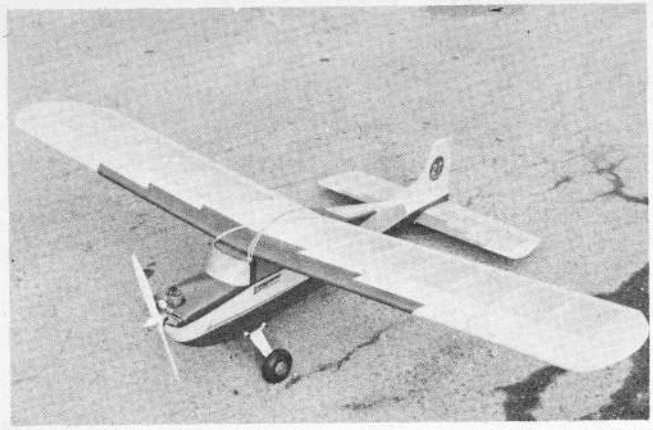
Editor's Note: Ever since we first heard of the tuned relay receiver, it appeared to be an ideal stepping stone from plain Rudder-Only control systems up to the more complex Multi's. Since our article on the T-R receiver in the May 1955 issue of ATH, we have received quite a few enthusiastic comments from users, who found that the independent control of rudder and elevator, plus the ability to control both at once as desired, enabled them to really rack a plane around. One user who was taken with the possibilities of this arrangement was Harold deBolt; using his own version of the receiver, which differs in tubes and layout but gives exactly the same controls as the Juenke-Bonner unit, Harold had well over a thousand flights in two different planes—most of them being with a Cruiser, but toward the end of the season, the system was installed in a Champion with equally good results. During the summer, the setup enabled Harold to take first place in seven meets, flying of course in the Multi-Control category. We feel the ideas set forth below will enable other modelers to break into the Multi-Control ranks in a relatively "painless" fashion.

■ What is meant by *automatic* R/C flying? It is simply this: A system by which a great deal of the work connected with the building, flying and maintenance of a multi-control R/C model is taken care of for you by the model itself. It is the result of using a lot of forethought in model design which combines with matching equipment to provide the easiest and simplest way to fly safely with multi-controls. A secondary result in this case: you come up with a combination which will come very close to matching the best flying which can be done with the most complicated rig at less than half the cost in both dollars and time! In a nutshell this is a typical R/C model which has been treated with some new ideas with the result that it can do everything that it could before but in a way that is safer and probably superior in a number of respects.

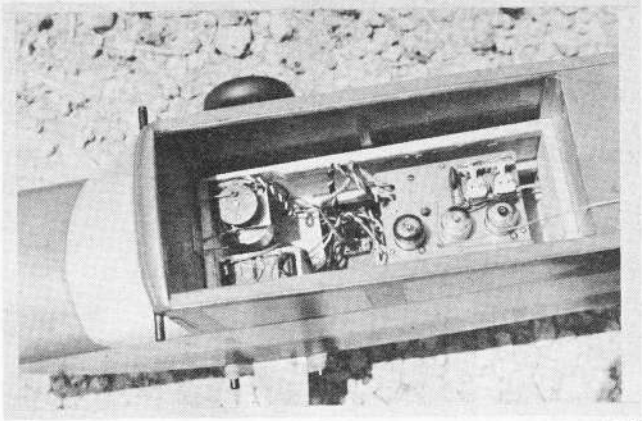
To take the project out of the nutshell it goes something like this: The heart of it all is the model and its flying speed. Although the things which have come along with it possess some fine features, they were only used to obtain the type of model that was desired. It was felt that the model should not be above *medium size* so as to be simple to use and inexpensive to own. This model should fly at a *slow speed* so as to have good take-off characteristics and to give the pilot time to think while flying it. On top of this the model should be *extremely maneuverable* with the ability to perform any maneuver slowly and smoothly from practically level flight. A lot of work has been done toward this end and the resulting model has been very encouraging and does perform just about as hoped for. In addition some unexpected advantages were gained that to say the least were not anticipated.

A Live Wire Cruiser was chosen for the project as a representative model which would give a good comparison between the old and the new. In analyzing the desired model it was decided that the Cruiser would need a wing loading of 14 oz. per sq. ft. or less if a flying speed of under 20 mph was to be achieved. All previous Cruisers using multi-channel equipment had a wing loading of above 16 oz. This 14 oz. loading meant a total model weight of 4¾ lbs.; with the model minus radio unit weighing 3 lbs. that left only 1¾ lbs. for the complete radio installation. After surveying the type of equipment which was available it was apparent that such a figure could be obtained if we used some of the very latest ideas, even though they were not too well proven. Using some of these ideas plus available equipment a complete R/C installation was assembled which weighs only 1½ lbs. and it does result in the model being more than what was hoped for. It is fairly simple to duplicate it if all this interests you.

The model, not necessarily a L. W. Cruiser, should be of medium size, 4 to 6 sq. ft. of wing area. It should have all the required design features that make a good R/C model, flight control should not be left up to the controls alone. The engine should be slightly more powerful for the model than would normally be used for the model at the heavier weight. This engine should turn the *largest* diameter 4" pitch propeller that it is capable of and still reach 8000 rpm. The reason for this is that a 4" pitch at 8000 rpm will give a flying speed of under 20 mph, yet the large diameter and associated blade area will provide the maximum static thrust necessary to pull the model around in slow speed maneuvers. The prop should be abnormally large in diameter for the engine even if it is necessary to drop back to a 3" pitch. Static thrust will also help the model to take off quicker as it gets the model up to flying



(Photo #3). This Live Wire Cruiser is equipped with tuned relay 2 channel receiver, has rudder, elevator and engine controls. Weighs 4¾ lbs. Wing loading is 14 oz./sq. ft.



Removable R/C unit (Photo #4) includes T-R receiver, 3PN multi-servo for rudder, 2PN modified servo for elevator, 3P for engine throttle. Total weight with batteries is 24 oz.

speed faster. For grass take-offs wheels of at least 3½" diameter are a distinct advantage.

The total flying weight of the model should be such that it provides a wing loading of 14 oz. per sq. ft. or less, actually the lower the better will be the maneuverability. By now it has been proven that it does not require a high wing loading to get penetration; practically the same penetration can be had through basic model trim and by the use of a trimmable elevator. As far as the controls are concerned the model should have rudder, elevator and three speeds of engine. The type of rudder actuator should be so that a second control can be had from it; this would be used to operate the engine. The engine speeds should be low, medium and high. Low for landings and proto take-offs, medium for normal flying and high for peak performance. To get the most from the elevator control it should be trimmable as well as self-centering.

After the model is set the next step is to determine how to operate the controls in the desired manner. There are a number of ways to do this of course, but most of the complex systems would involve too much weight for this type of model. In choosing the equipment it is necessary to consider the whole system in relation to each component rather than to select some one part because it is convenient and then just add the rest to it. One wrong choice could spoil the whole concept. In this case Multi-Servos were choosen for their good power, light weight and low battery drain. Experience has shown that it is very important from the safety factor and for reliability to operate rudder and elevator on two separate channels. Any other control can be used in combination with excellent results. It worked out that a 3PN servo using one channel for rudder and engine control proved very satisfactory. This servo was used without a compensator as shown in Photo No. 1. The 3PN was used to operate a Model 3P as the engine control actuator. The 3P in turn actuated a Bramco throttle which gave the three speeds of engine very nicely. The throttle was connected to the servo through a .040 wire pushrod which will flex and give the needed lost motion.

The trimmable and yet self-centering elevator action was obtained by using a slightly modified Model 2PN Multi-Servo. This is by far the most important servo action needed to get the automatic performance. The modification to this servo is shown in Diagram No. 2. A characteristic of this model servo is that it can be trimmed from a neutral position by using a very short beep of signal. Normally this will give a few degrees of trim in one direction. In this case, however, advantage was taken of this feature and the trimmable portion was expanded. This is done by increasing the "dwell" (number of degrees that the contact is open) of the *neutral* contact on the servo. When the dwell is increased more short beeps can be used and a greater trim range is available. In addition a condition will exist whereby you have two positions to which the servo will neutralize depending upon the control position from which you allow the servo to return from. If you allow the servo to cycle 360 deg. from neutral to neutral, for instance, it will stop at one vertical position, yet if you allow it to neutralize from the 2nd operate position it will return to a vertical position which is just short of the first one. This "neutral" position will be on the 2nd operate position side of vertical.

All this proves to be a distinct advantage if you have the servo mounted so that the first operate position is up elevator and the 2nd operate position is down elevator. With this arrangement you can cycle the servo 360 deg. and arrange the elevator so that this is neutral elevator. Then any time you send one long beep and release you will come back to neutral elevator; your neutral is always instantly available and positive. The second "neutral" position provides a means of having down trim; for this you pulse twice, hold and release. This allows the servo to cycle from the 2nd operate position (down elevator); from this position it will stop at the "neutral" which is short of vertical and on the down elevator side so that you automatically get a down trim condition. From this down trim condition you can use one short beep and get back to neutral elevator or add more beeps to get any up trim that you might wish.

To alter the 2PN servo you will of course have to change

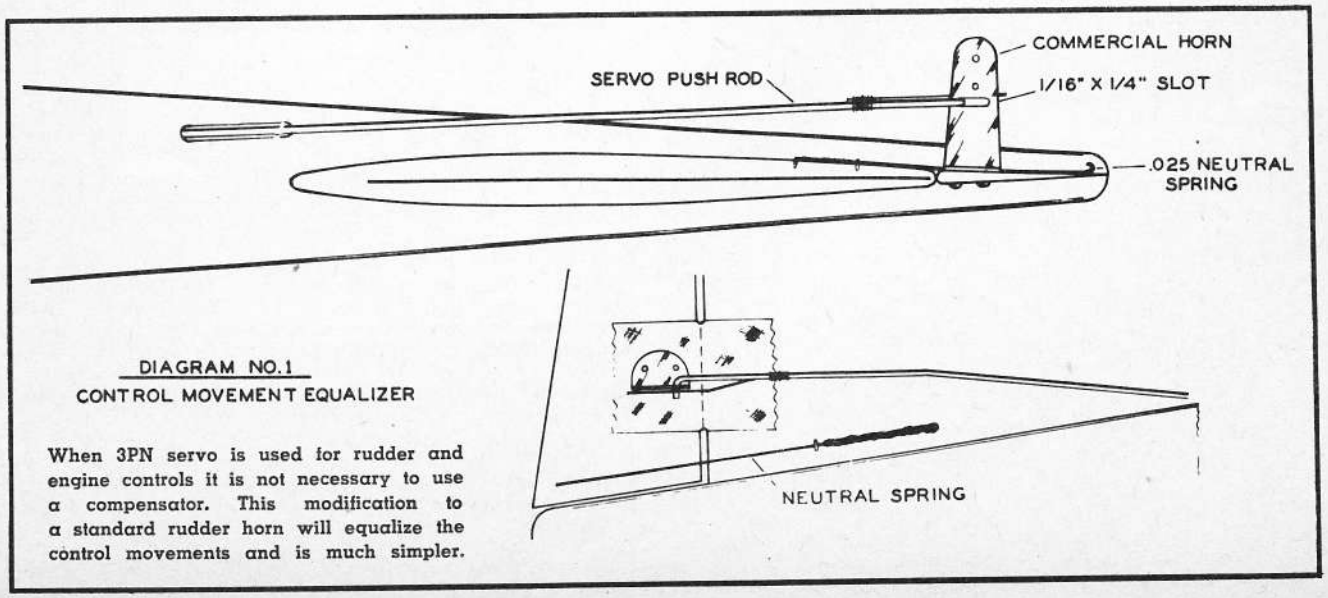
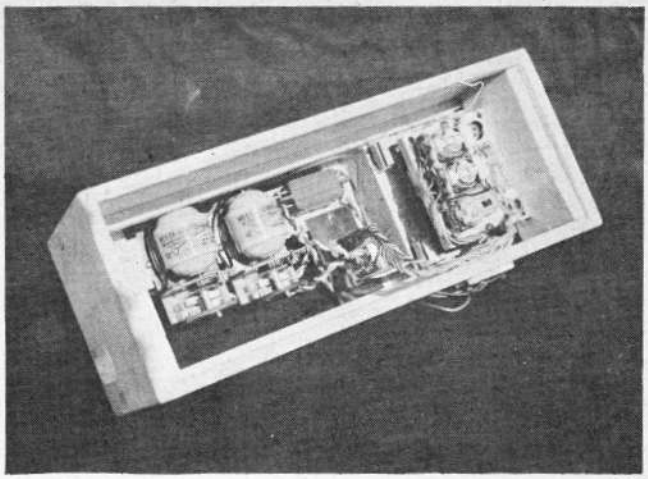


DIAGRAM NO. 1
CONTROL MOVEMENT EQUALIZER

When 3PN servo is used for rudder and engine controls it is not necessary to use a compensator. This modification to a standard rudder horn will equalize the control movements and is much simpler.

This Live Wire Champion is equipped with a C-G 2 channel transistor receiver, Rudder, elevator, engine controls. Wt.: 3 lbs. Wing load.: 11.5 oz./sq. ft. Torp. 15.



Champion's removable R/C unit. C-G transistor receiver, 3PN multi-servo for rudder, 2PN modified servo for elevator, 3P throttle. Wt.: 14 oz.; with engine servo, 16 oz.

R/C FLYING

the factory adjustments, but then too if you use servos you should understand how to take care of them. The most important thing to be sure of when you have made a contact adjustment is that there is sufficient contact tension and pressure after you have finished the adjustment. A simple way to check this is to watch the stationary contact as the servo is operated. If the movable contact has sufficient tension and enough pressure is present the stationary contact will flex every time the movable contact closes against it. It is impossible to get too much tension into the 2PN movable contacts, so the more that the stationary contact flexes the better will be your operation. The correct tension is obtained by gently lifting the movable contact from under the stationary one and bending it back until it will stay at a 90 deg. angle to the base. It then can be gently forced down and into place under the stationary one. If done carefully the tension will then be correct. All contact timing adjustments are made by moving the stationary contact; moving it up causes the contacts to open quicker, moving it down makes the contacts stay closed longer.

The brake is used to control the indexing of the cam when it returns to neutral. If the cam runs past a vertical position when the servo is cycled, a bit more brake tension can be added until it stops in a vertical position. If the cam stops short of vertical when it is cycled, a bit of tension can be removed until it does reach vertical. These adjustments can be made with the careful use of long-nose pliers. After you become familiar with the servo you will find that the complete indexing of the cam can be controlled by a combination of brake tension and contact opening time.

Now we have three actuators of the desired type which will give the control action which we want. It was found that the elevator can be a simple unbalanced affair of generous area. No evidence of jamming has occurred, mostly due to the lower flying speed and non-jamming design of the servo. The rudder was conventional and the engine control was described before.

With the method of operating the controls established it was necessary to choose a receiver which would provide the necessary relays to operate the servos and yet would not be too heavy for the project. In this case two relays would be required and two channels. The receiver which showed the greatest promise at the time was the two-channel Tuned Relay receiver which appeared at the '54 Nats; this was an extremely light weight unit with a low battery drain, just what was needed. With no specific information available, the author with lots of help from others worked out a similar receiver that has been used exclusively to date. Since then YOUNG MEN has published complete data for a similar receiver which for all purposes will do the same job as the one which was used. Otherwise there now are commercial receivers appearing on the market which could substitute very nicely.

The main requirement of the receiver other than the two relays is light weight. To fit the picture it should not weigh over 12 oz. complete with batteries. Most of the receivers which will fill this bill make use of the small subminiature relays, and when these are used the receiver must have some excellent characteristics if the relays are to be reliable. These little relays can do an excellent job, but to do so they require a lot of current. To match the relays the receiver should have a current change that rises from zero up and preferably to 3 or 4 milliamperes at least. The reasons are that they tend to have an erratic drop-out point and also require plenty of operating current in order to have sufficient spring tension to provide the needed back contact pressure.

Relay contact pressure is very important for reliable operation with any type of actuator. Too often it is taken for granted and as a result it can be the little "gremlin" that proves so hard to locate. There always should be sufficient contact pressure on the relay to be sure that there will be *no* contact resistance at any time. A relay may have good pressure on the bench but be close to the minimum; then when it is used with the vibration present in the model there may be contact resistance. Even a few ohms of contact resistance can give trouble with the low voltages that are used for actuators. The T-R type receivers are good in this respect in that they have a current change from zero to many milliamperes in some cases, at the minimum there is plenty.

One of the things which is often overlooked by many modelers is the manufacturers' operating specifications for their relays. It is bad enough that these specifications are given to us for use at 28 volts without our wandering away from them on top of it all. The maker sets up an operating point for the relay which will give us many things, such as correct contact pressures, vibration immunity, greatest sensitivity and other things which may seem trivial but which all add to the performance of the relay. If a relay is used with a receiver whose performance does not match the operating specs for the relay, trouble is certain to occur even though you may get the relay to operate in some manner. Remember that the specs are given for 28 volts on the contacts, hence the better you can match your receiver to the specs the better chance you will have of getting trouble-free performance.

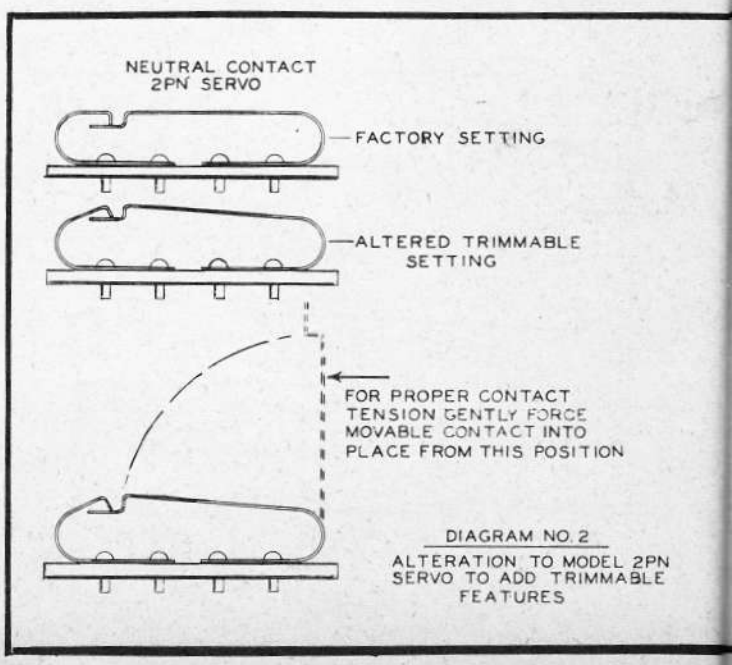


DIAGRAM NO. 2
ALTERATION TO MODEL 2PN SERVO TO ADD TRIMMABLE FEATURES

The batteries which have been used with the T-R receiver have not been the lightest possible by far, yet the weight has been held at 12 oz. A bit of weight has been sacrificed here in order to get a battery complement which does not have to be changed so often, adding safety and cutting work. A unique arrangement is used for the servo batteries which helps to hold the weight down yet gives long life and allows simultaneous operation of the servos without overloading the batteries. This consists of 16 pen cells which are used for all servos; they are wired as shown in Diagram No. 3. The life span of the servo batteries will then more than match the ones used for the receiver.

To operate the receiver a Babcock single-channel transmitter was used originally. Since then a switch has been made to a home-built unit in order to get utility by having three different types of transmitters in one case, this being the only reason for the change. The Babcock was modified so that it would send three tones instead of one. In the Babcock there is a 500 mmfd. condenser which controls the tone; the two additional tones were obtained by adding two more switches that duplicate the original one and yet have another circuit (STDP type). Suitable condensers were placed in these extra circuits so that the original one could be bypassed and a new tone established. By trial and error the capacity of these condensers was determined so that the new ones matched the receiver.

To date all flying has been done with pushbuttons both with the Babcock and on the control box used with the home-built rig. It is hoped that the future will provide sufficient time to work out a "stick type" control box as this would help a lot in the flying. In the photo (No. 2) the button on the right is for rudder and is used with the right hand. The one on the left is for elevator and the third one gives simultaneous operation.

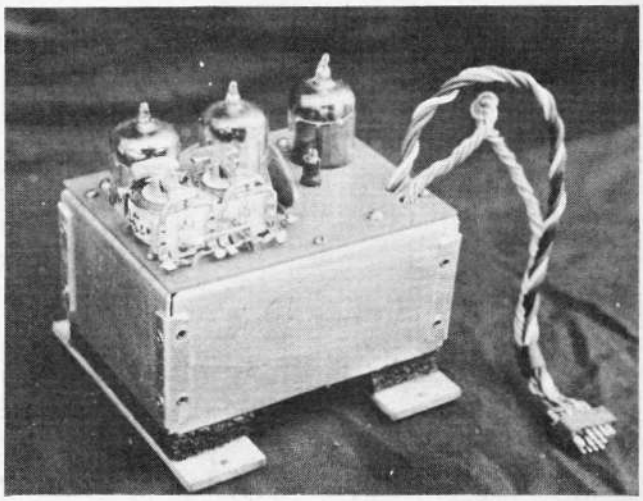
The simultaneous operation comes with the use of a T-R type receiver and is described in the article on the receiver. It has been very reliable as used with this project. With this arrangment when the third button is pulsed and held it gives up elevator and right rudder together. Two pulses and hold gives down elevator and left rudder together.

Probably a more useful feature of the action is that the elevator can be held in any position and the rudder can still be used to steer the model simply by using the third button in place of the regular rudder button. In other words it gives simultaneous controls with the rudder independent from the elevator. Technically what is done is this: The low tone is used for the rudder channel, the high tone is used for elevator. They overlap slightly in the middle. Then a third tone is arranged for the third button which will fall in this overlap and cause both relays to draw current. This third tone is also arranged so that it not only falls in this overlap but it also is of such a magnitude that the combination of it and the high tone will be a correct one for the rudder.

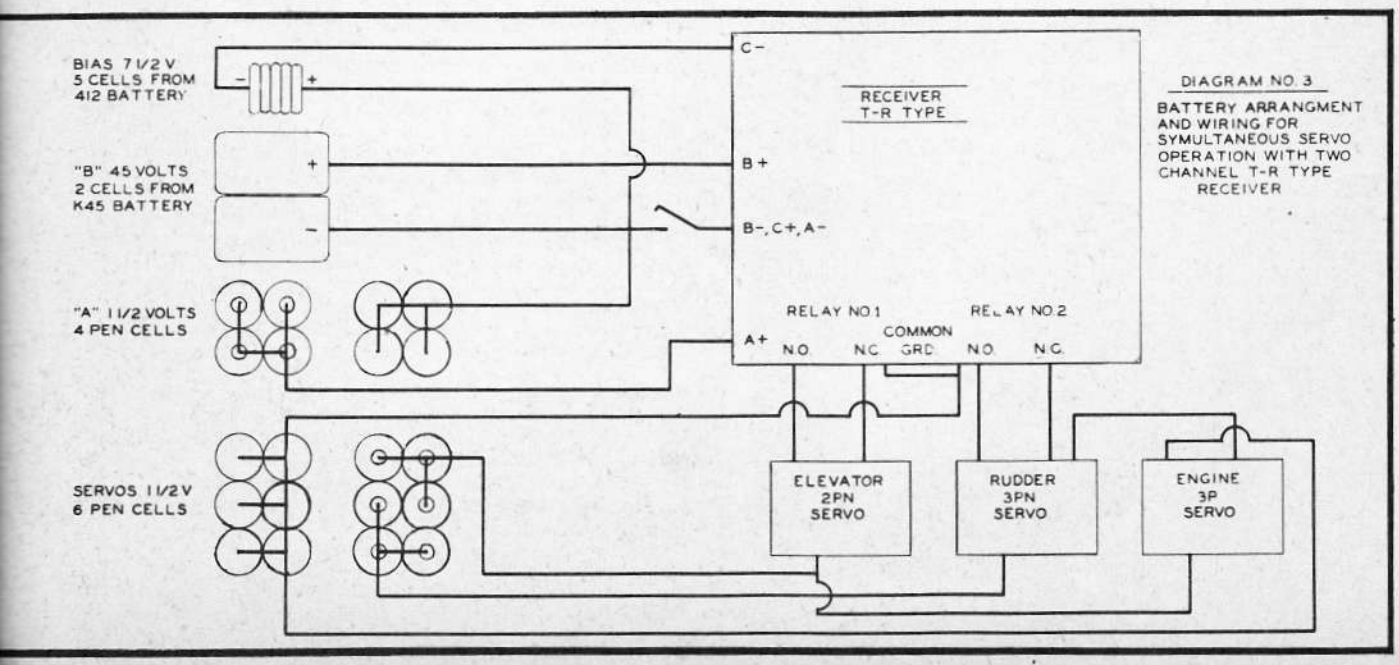
With the equipment all settled, all that is left is to see how it is used. First, in order to get the full benefit from the trimmable elevator the model is adjusted to fly very flat in neutral elevator. This is done with the Cruiser by adding positive incidence to the stabilizer; the ultimate seems to be so that there is about 1 degree of difference between the wing and stabilizer. With such a change the model will fly very flat and quite normal except that it will not stunt very easily on rudder alone. About the only change used is to beep in a slight amount of up elevator for take-offs, climbing and rudder only maneuvers. This gives the same effect as the original setting did. With this flat trim the model will have above-normal penetration and you will be able to cover the ground faster. When you prepare to do a maneuver two beeps, hold and release are given first, which provide the down elevator trim. With this trim the flying speed will build up slightly and you will find it to be plenty for all normal maneuvers such as loops, rolls, etc. There is no need to dive the model at excessive speeds in order to get enough momentum to carry you through a maneuver. It has been found that where consecutive maneuvers are desired it helps a bit if the second pulse is held (down elevator) a bit so that the model actually gets its nose down before you go into down trim. The slight additional speed is sufficient for all consecutive maneuvers.

One of the most likable features of the system is the automatic recovery from maneuvers; you do not have to fly the model out of the maneuvers in order to get flat and level recoveries. The servo does the work for you by returning to the proper trim condition necessary for the recovery. What happens is that by its very nature the servo returns to a trim condition that is suitable for recovery, no matter what the maneuver. When you wish to complete a loop all that is necessary is to release the button at the bottom of the loop—the model comes out flat automatically in spite of the excessive speed. For a vertical dive you hold down elevator on; when released the servo returns to a down trim condition which with the excessive speed built up allows the model to make a gradual pull-out

(Continued on page 70)



DeBolt's 2-channel tuned relay receiver with 4 tubes. Bare wt., 5 oz.; with box, 6½ oz. A drain, 140 ma.; B idle, 1 ma.; B rise 0-6 ma.; Neomatic relays. 2x3x1¾".



AUTOMATIC MULTI-CONTROL

(*Continued from page* 39)

into level flight. Once in level flight the elevator may be trimmed to obtain whatever sort of flight you desire. Fantastically enough it works out so that no matter what the maneuver may be the recovery is flat and level.

Good inverted flight has come consistently well. This was done by arranging the amount of down elevator so that the maximum movement is just right to hold the nose level while inverted, which is more than enough needed for a vertical dive. Going into inverted flight then becomes easy; you start a loop by pulsing once and holding the elevator button. As the model goes over the top of the loop you release the button momentarily and press it down again, holding it as long as you wish to stay inverted. What happens is that you are in the first operate position of the servo when starting the loop; when you release and pulse again quickly at the top the servo moves from the first position to the second (down elevator) without having to return to neutral.

The catch to getting good inverted flight every time is to apply the down elevator at the right moment. If it is applied too soon the model will stall out and go into a roll. It is better to apply control too late rather than too early as the model will at least have plenty of flying speed then. If model tends to roll no matter how you do it, you either do not have good straight flight trim or else the model is stalling. If straight flight trim is O.K. simply reduce the amount of down elevator until the model stops rolling. While flying inverted the simultaneous button comes in handy as you can steer the model with it while holding the elevator button down.

Snap rolls are another maneuver which can be added by the use of the simultaneous control. They are done like this: from a down trim condition and above normal flying speed the third button is pulsed and held. The resulting up elevator and right rudder gives the roll automatically! Don't ask what happens if you pulse this third button twice and hold, that would be *down* elevator and left rudder! A further use of this third button can be had in sharp turns where it would be an advantage to have some "up trim" to hold the nose up. To do that you would start the turn with the rudder button and