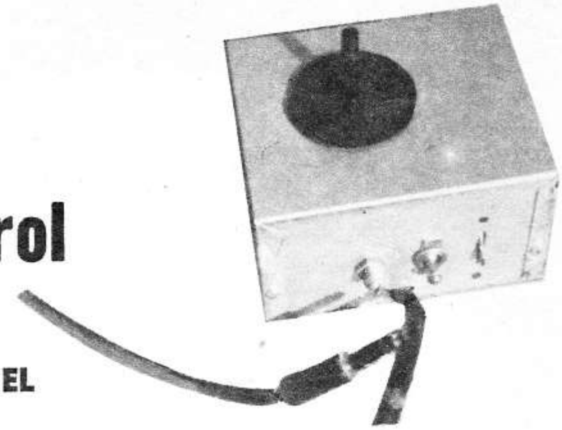
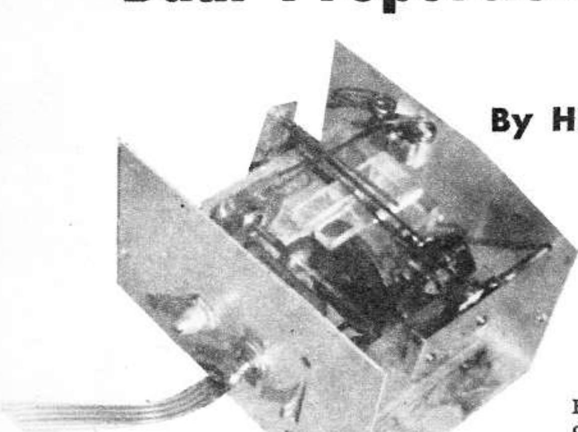
SPECIAL! FOR THE R/C EXPERIMENTER—

Perfected Simplified Dual Proportional Control





By HELMUT KEUHNEL

If you're ready to step upward and onward from single control, rudder-only craft, this timely system offers dual and simultaneous features hard to beat

There is no doubt but that multi-controls will be THE thing for 1955. The proportional-operation-of-more-than-one-control system shown here does the trick in about as simple a way as possible. Helmut Keuhnel has been flying the equipment described for nearly a year; though not too active in contest flying, he did take a first place with his dual simultaneous proportional system. He was able to top all other R/C flyers at the big 1954 National Capitol Meet on a blustery cold day in July, and attributes this win solely to the fact that he had such close vertical *control of his plane—something that is most handy in either contest or sport windy-weather flying.—The Editors.*

More and more R/C experimenters, while not dissatisfied with their rudder-only planes, are looking ahead to elevator control. But the problem is more complicated, if the modeler prefers the proportional system, since it has not been anywhere near as easy to add a second control to proportional systems as it is when escapements are used. And when we consider *dual* and *simultaneous* proportional control, the picture can get a bit grim.

The ideas to be presented here have been under trial for more than a year and have proven very successful. Two methods for dual proportional will be given; the first is a fully electrical system which has been in use the longest. By now most builders are familiar with the requirements of proportional control systems, so we won't go into this. Those who need a bit of background can refer to articles on the subject in the January, October and November, 1954, issues of this magazine.

Modelers who are hep will know that proportional control is usually accomplished by varying the length of the pulses sent to the plane, with short pulses giving one rudder extreme and long pulses the opposite; normally, pulses that are about the same length as the space between them give neutral, or center rudder. In most systems, a variation of the pulse *rate*—that is, how fast the pulses are sent out—does not change the rudder position appreciably. By the simple means shown in Fig. A, we can make use of rate change to control the position of the elevator, and this simple system allows *simultaneous* variation of both rudder and elevator position. It will be seen that the receiver relay operates a single-coil actuator for the rudder; the system may be applied to a double coil actuator just as well, but in this case the added equipment would be connected across only one of the two actuator windings.

Also, note that if there is spark suppression equipment on the relay contacts, it should be removed from the side to which the elevator operating circuit is attached. The reason for this is simple—it is that arc you see at the relay contacts that is put to use to work the second relay and move the elevator actuator.

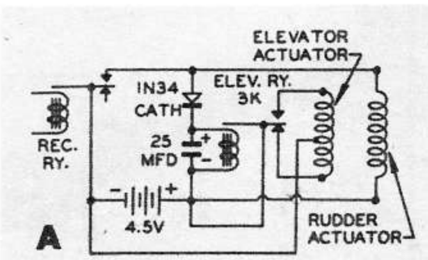
Every time the receiver relay contacts open, the rudder actuator shoots an inductive pulse backward (in the opposite direction to battery polarity) through the circuit; this pulse can burn the relay contacts or make them stick together. In Fig. A the inductive pulse is put to use; it passes through the 1N34 diode and charges the electrolytic condenser. The pulse is of very short duration but has quite a kick (ever get your fingers across the relay contacts as they opened?) and furthermore, it is of about the same potency regardless of whether the rudder operating pulses are long or short. The diode is required—and must be connected exactly as shown with respect to the 4½ V battery—to allow the pulse kicks through, but block the battery voltage from the condenser and elevator relay.

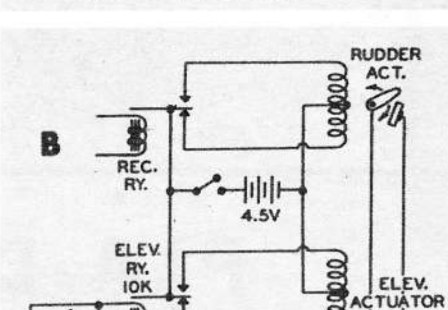
Now look at Fig. G. At the top are the conditions for a pulse rate of 1 pulse per second (1 PPS); the rudder pulse is on half the time and off the other half. The elevator pulse—which comes just as the rudder goes from on to off—is quite short, and so the elevator could be down for the duration of this short pulse and up all the rest of the one second interval. In the center set of conditions, the rudder pulse rate has been doubled (but the rudder is still off half the time and on the other half, so is still in neutral) and the added kicks to the elevator relay bring it to pretty near neutral, actually a little more on the up side.

Still further speeding up of the rudder pulse rate brings the elevator to almost full down; note that with all three pulse rates shown, the *duration* of the elevator pulses is always the same. With higher rates there are just more of them. To show it another way, look at Fig. F, which shows the elevator position as rudder rate is varied; it can be seen that neutral elevator corresponds to 2½ PPS on the rudder.

The system is arranged to give full up elevator at zero rudder pulse rate, since this is considered a fail-safe condition, should signals stop for any reason. It could be set up the opposite way if you prefer.

To retrace our steps quickly, then, the rudder actuator operates just as in a normal proportional control circuit. Each time the receiver relay opens, an inductive kick passes through the 1N34 diode and charges up the 25 mf. condenser; this condenser charge leaks off through the winding of the 3K relay (it can't go any other direction since the diode appears as a very high resistance to keep the condenser charge from "backing up"). The elevator relay is held closed for the same length of time on each rudder pulse, regardless of rudder





pulse speeds, up to about 5 PPS. Therefore, the length of time the elevator is held to either extreme position depends solely upon the rudder pulsing rate.

Just any actuator cannot be used for the rudder in this setup, since the actuator must not only move the rudder but give a good hot inductive kick when the relay points open. It is necessary to use an actuator with plenty of iron and copper, and the simple design shown in Fig. D will do the job nicely. (So will the Mactuator shown in the Nov. 1954 issue, but that one is a more complex building job.)

Since this actuator has only a single coil, it must be used with spring loading to hold the rudder to one side when there is no signal; the 25 ohm coil draws about 180 ma. at 4½V., gives plenty of power to move the rudder, and just as important in this system—gives a good inductive kick to operate the elevator relay. The design is very simple; the main frame is a "U" of .065" soft iron with two added thicknesses of the same material where the coil is to be wound. These are put on and covered with insulating tape after the 1/32" Micarta coil ends are installed. The winding is composed of 150' of #32 enam. copper wire.

While the dimensions shown work out to give a gap between the magnet and core of 1/64" on each side, the original actuator has about 1/32" and works very well. The disc magnet has a bearing block of ¼" thick Plexiglas, with four 2-56 tapped mounting holes, and a center hole for the magnet shaft. Not shown on the drawings are two stops to limit movement of the control arm and a string that pulls the arm to one side of the center position shown. The finished actuator weighs about 2 oz.

The elevator actuator may be of the same type, but a commercial (Southwestern) double-coil actuator has been used, and connections for this type are shown in Fig. A. A 3000 ohm Sigma surplus relay has been used for the elevator control, with the heavy Bakelite base trimmed down as much as possible; most of these relays come with a polarizing magnet, which should be removed.

Relay adjustment is most important, so study the following procedure carefully: 1. Hold armature toward core and adjust the normally-open contact so the armature barely clears the core, but does not touch it. 2. Loosen the tension spring until the armature is just barely held away from the core. 3. Set the normally-closed contact until the gap between armature and core is about 1/64". 4. Now check the current required to operate the relay—it should be about .5 ma. (Don't worry over this low value—it will be increased later.)

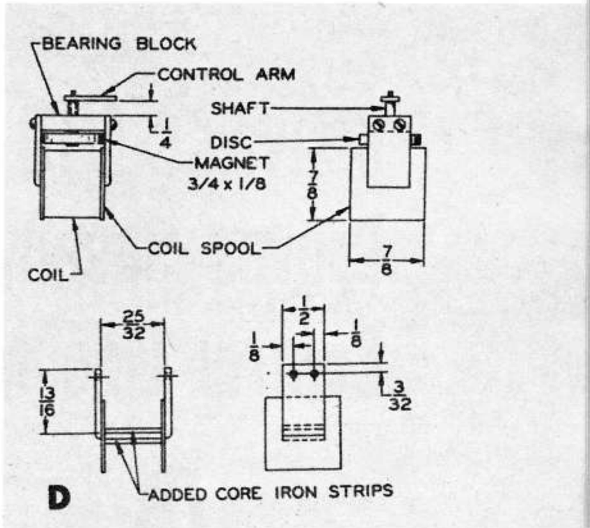
Any type of diode has been found to work OK, with the 1N34, CK705 or any general purpose type entirely adequate. Two of these may be used in parallel to get more current capacity. The negative or cathode end of the diode is marked by a bar or ring around the case. Be sure you connect diode, battery and electrolytic condenser just as shown on the diagram.

The pulse box to be used with this system may be of the regular motor-driven type, electronic or relay-operated, as you prefer, but there must be arrangement to vary pulse speed as well as length. Suitable pulsers of all these types have been described in past issues of this magazine. The pulser must be adjusted so that pulses never cease entirely; in other words, you should never have either full signal or no signal.

The pulser that has been used with this equipment is of the motor-driven style, but variation of pulse rate is had by means of friction discs, so that the rate change is instantaneous. Both rate and length change are affected through a single control stick—by far the most desirable arrangement. If you have a plain motor-driven box, you can add a variable resistor of 5-10 ohms to change the rate; this will give a slight lag in elevator action, but has been used successfully.

Adjusting the completed system is quite simple. First, open and close the receiver relay by hand and note if the elevator relay gives a blip every time the receiver relay is opened, and see that the rudder actuator returns to the spring-loaded stop when the receiver relay is open. Another check is to connect a low range volt-meter or milliameter across the elevator relay. The meter should show a momentary reading of about 2 V. or 1 ma., upon each opening of the receiver relay contacts.

Now operate the rudder actuator through the radio system, and your regular pulse box. Set the pulse rate at the lowest with which you wish to fly (it shouldn't be slower than about 1 or 2 PPS) and tighten the elevator relay spring until the relay acts hesitant about pulling in. Increase the pulse rate until this relay holds in continuously—the rate should be at least 5 or 6 PPS. While pulsing at this higher rate tighten the spring until the relay just fails to hold it solidly; go back to the slow rate and the relay (*Continued on page* 77)



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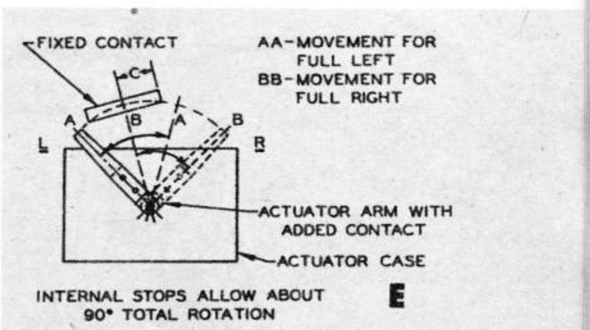

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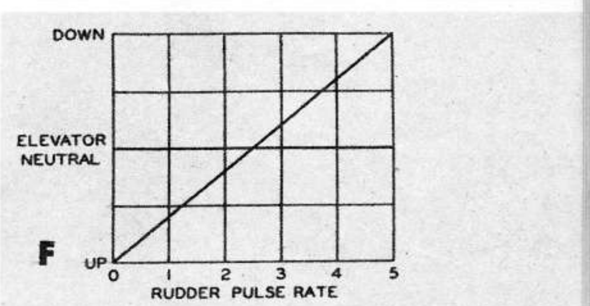

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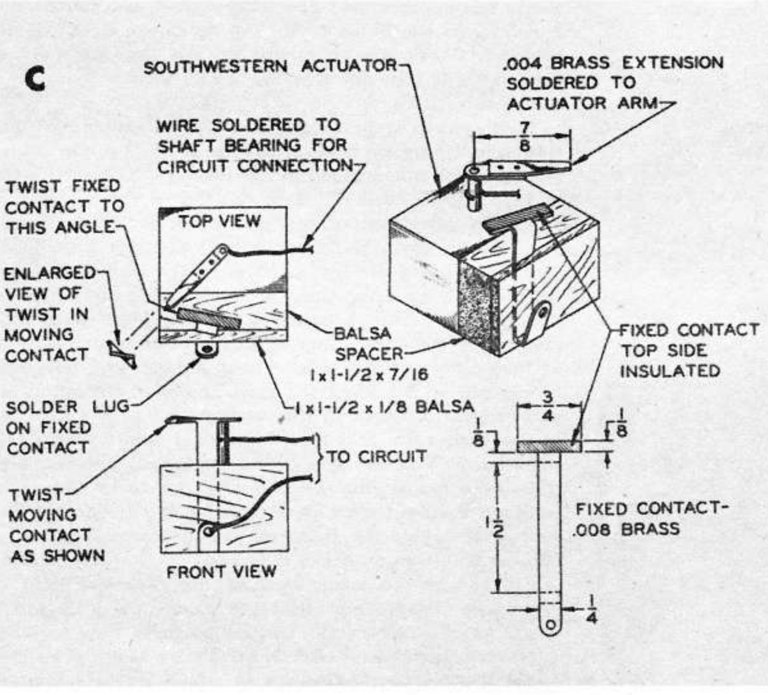

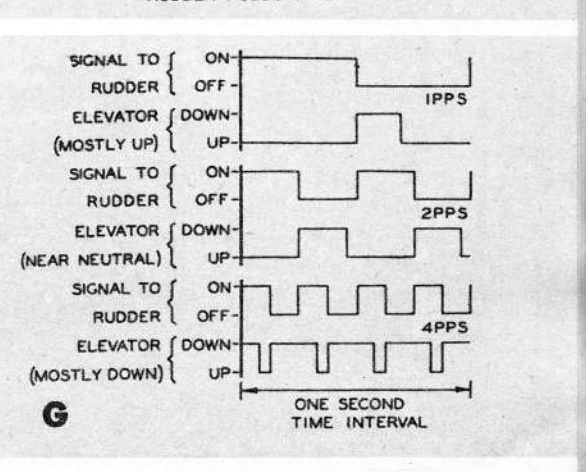

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universities offering majors in ceramics, give the different kinds of jobs and duties, and present various other highlights in the "unknown story" of ceramic engineering.

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should remain open.

A process of tightening the spring a bit at the high rate and loosening it at the low rate will result in a setting where the relay will not pull in at all at the lower rate but will remain pulled in solidly at the high rate. At intermediate rates, the relay will snap back and forth, favoring one contact or the other according to the pulse rate. The elevator actuator should now be connected, and the elevator checked, after which you are ready for a field check and a flight.

The length of the elevator blip may be stretched out more by using a larger condenser, decreasing armature clearance or decreasing spring tension. If you want to operate the system with a small range of pulse rate, you will want a long hold-in time for the elevator relay, and vice versa. The system has not been found critical to vibration, and has been flown with the relays mounted on sponge rubber.

The more mechanically-minded reader might prefer another system we have used to work the elevator relay, and which is shown in Fig. B. Here it will be seen that a pair of auxiliary contacts are attached to the rudder actuator—in this case a double-wing Southwestern, as is the elevator actuator. The contacts supply pulses to the elevator relay and its holding capacitor, power coming from a small 45 V battery. The pulse diagrams are just the same as shown in Fig. G for the all-electrical system, but in this case the heart of the arrangement is the contacts of the rudder actuator and the way they are adjusted.

Fig. C shows how the contacts are installed; note that the fixed contact is off-center somewhat, and is bent to coincide with the arc of the moving contact. The latter is a piece of .004 shim brass soldered to the actuator arm. A connection to this contact may be made by a wire soldered to the shaft bearing tube. The fixed contact must be insulated on one side only (either side, but top insulation is indicated here); the tip of the moving contact is twisted a bit so that as the arm moves in one direction the tip will ride over the top of the fixed contact, while when it returns, it goes underneath. About 10 degrees twist should do the job. Heavy pressure is not needed, since the current is very low.

After the fixed contact has been attached to the actuator case, wrap the whole thing with Nylon and dope it well. Since there will doubtless be a bit of end play in the actuator shaft, make sure the contacts operate as intended at both extremes of this end play. Needless to say, the contact parts should be smoothed off well with a fine file and sandpaper; the insulation on top of the fixed contact may be a couple of coats of glyptal or even nail polish, allowed to dry well before you move the other contact over it.

A 10,000 ohm blanket control relay was used in this circuit, and the electrolytic condenser must be polarized with its positive going to the 45 V battery positive. The same sort of variable speed

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pulser is needed for this arrangement. The rudder actuator has stops set to limit movement of the control arm to about 45 degrees each side of center; the linkage is adjusted so that the rudder has an actual movement of about 20 degrees each side of center. The required travel of the actuator arm is shown in Fig. E.

It will be seen that for extreme left the moving contact passes completely over and under the fixed contact on each pulse; however, for extreme right it covers only an area C on the conducting side of the fixed contact. Thus it will be seen that it is not necessary for the arm to go both over and under the contact, as long as a reasonable pulse is sent to the elevator relay for each rudder pulse.

The pulser must be arranged so that even at full left or right, the actuator arm can travel over about ⅔ of its full movement; while it might be thought that you won't be able to make sharp turns with such a rudder movement, this "partial" rudder with down elevator will tighten up a spiral in a hurry! Actual elevator area for each plane is difficult to set, but as a starter, make the elevator about 20% of the stab area and use 2-5 degrees of up and down movement.