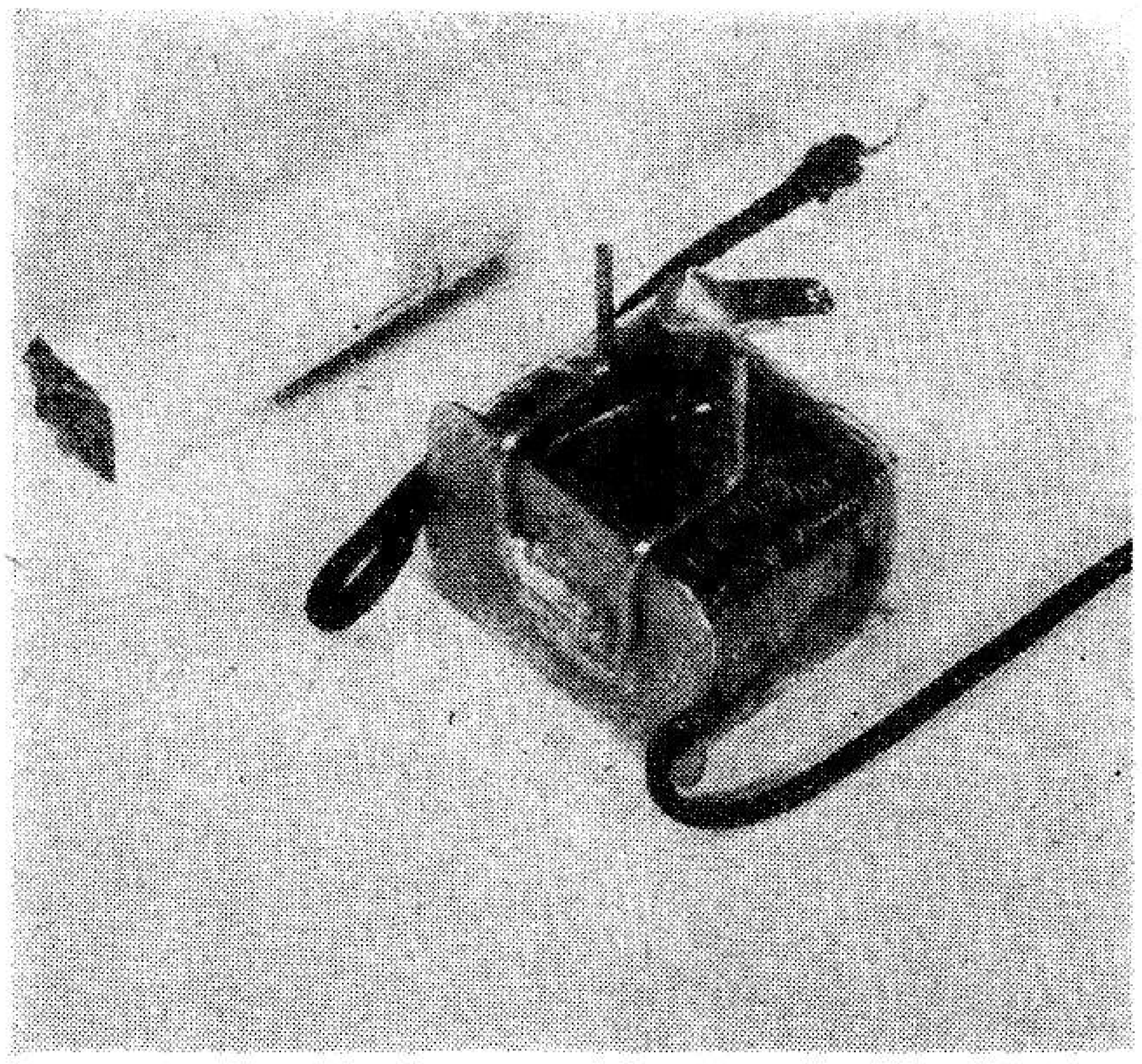
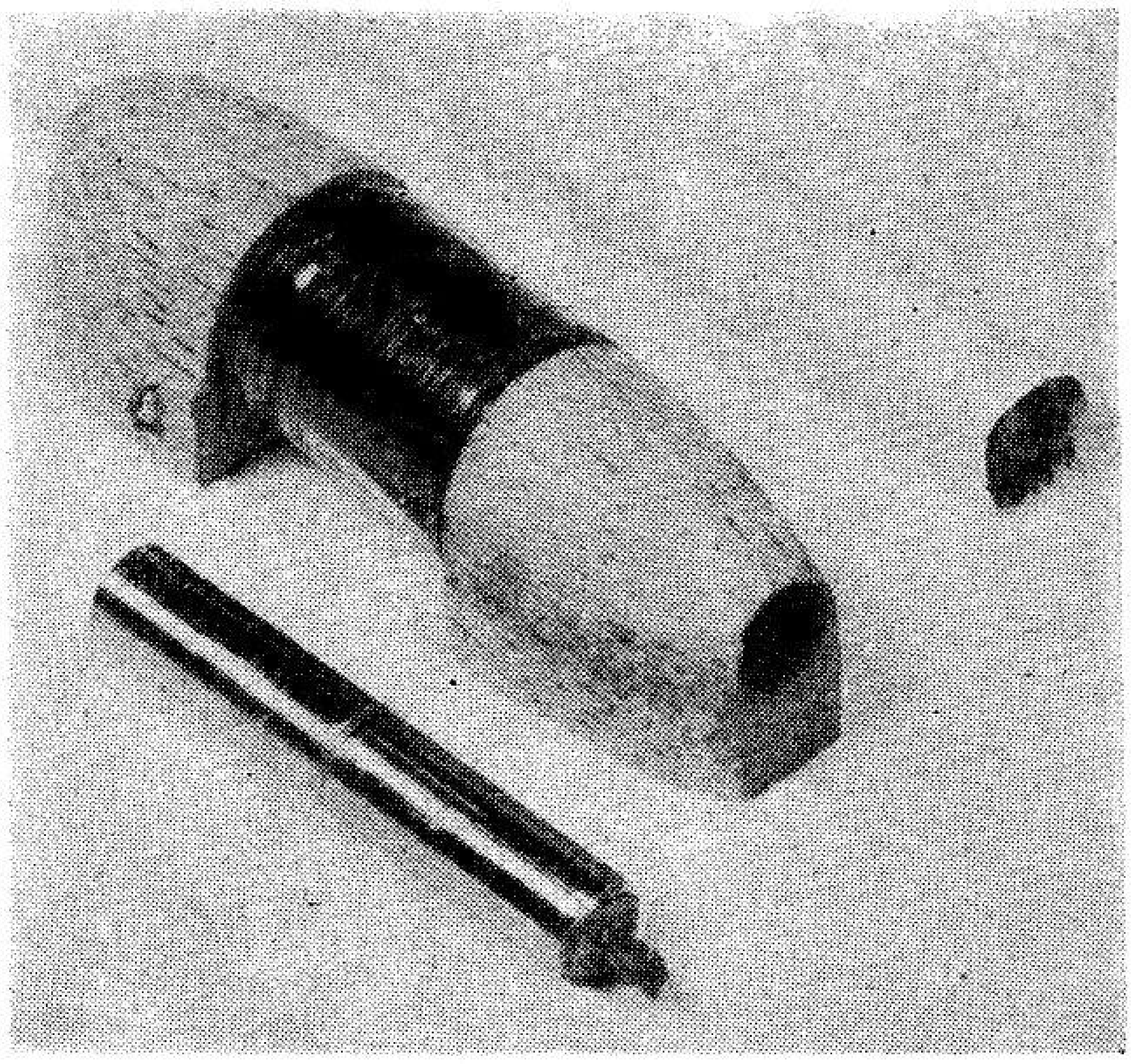


This rotary actuator has no iron aside from disc magnet and shaft



Cigarette shows size of slide-type actuator; note double magnet

SIMPLE PROPORTIONAL CONTROL

THE JET and the rocket engines were demonstrated much earlier than the reciprocating engines. Because useful results were obtained more easily with the reciprocating type in those days, nearly all development was concentrated on it. It was not until the forced development stimulated by a world war that the possibilities of the jet engine were realized.

Could it be that we have been overlooking some possibilities in some of the early proposals for R.C.? In 1935 the writer can remember an article which advocated a form of *pulse proportion*. That seemed to be the right road to travel, for the ultimate goal of performing aerobatics with a radio control model that would match those of the *Travelair* or the *Waco* of that day.

This ambition finally came close to a reality, when at the 1947 Nationals "yours truly" received full credit from the judges for successive loops, Immelman turns, Chandelle turns, wing-overs, whip-stalls, (and also some that were not in the book).

If a few of us put our heads to work on it we may all be surprised at the results. The writer will attempt to convey to you the results of fifteen years of study and experimentation on the *Pulse Proportion and Pulse Rate* systems. Jim Walker has several patents on a form of pulse proportion, but pulse rate is presumably original with the writer.

In 1947 the *Actuators* used were of a type rather difficult to build. (See M.A.N. for June, 1947.) Since that time they have been developed into a simpler form and can be built with the tools to be found in the average shop.

The first and foremost advantage of the system is, as the name implies, proportional control; this means that the control surface on the plane operates in the same proportion as the control in the operator's hand. You can make gentle turns, or tight turns, or spiral dives at will. You can give it full rudder to start the turn quickly, then when the plane has assumed the desired bank, release some of the pressure on the rudder so it will maintain just the degree of turn required. Also, the rudder can be varied continuously in order to compensate for the rough air encountered at times.

There is no sequence to get fouled up on. As you move the control stick, so moves the control surface in the plane. If your radio misses a signal now and then, it has very little effect on the action of the plane, nor does random interference cause much trouble.

The system will work with any R.C. transmitter and receiver as long as the relay in the receiver has double contacts (single-pole, double-throw).

The escapement of the now popular system is done away with and taking its place is a special little gadget developed by the writer. The most appropriate name that came to mind for this gadget was *actuator,* because that is just what it does —it actuates the control that is connected to it in the plane.

There is nothing that ever requires adjustment once an *actuator* is built. There is nothing about it that is affected by vibration or wind. It will not suddenly quit working due to low batteries. The weight is somewhat less than that of any other type of rudder mechanism known, and it will operate on considerably less battery power. It is the writer's experience that an *actuator* requires about a third as much battery power as the average escapement. Also experience has shown that most planes of the sizes flown today can be controlled by an *actuator* weighing less than an ounce.

PART ONE

The *actuator* is in effect an electric motor which makes only half a turn in either direction. When the voltage is applied, the armature will jump to one of its limits; when the polarity of the voltage is reversed the armature will jump to its opposite limit. This movement is connected to the rudder horn through a push-pull rod so that the rudder moves only a small amount for the entire movement of the armature in the *actuator*.

The relay in the radio receiver connects the battery voltage to the *actuator* with one polarity when there is no signal and with the opposite polarity when a signal is received. The writer started out with the batteries connected in a manner that a signal gave right rudder, and no signal, left rudder. (Can't figure any good reason for this arrangement, or the opposite either, so for the sake of explanation let's assume this connection.)

Now then, if we use an ordinary push button to key the transmitter and set the limits on the rudder's movement so it cannot turn the ship tight enough to spin it in, we can fly straight by keying the transmitter on and off evenly. Push the button, and before the ship can start the turn to the right, release the button; again, before the ship can turn to the left, press the button. Thus by merely keying the transmitter on and off evenly the ship maintains a straight course. For a right turn you just hold the button down, or for a left turn, release the button as long as you want the ship to turn.

This method has been used on a few flights, and it was a lot of fun, but it leaves much to be desired when it comes to stunting. If the limits are moved out on the rudder so you can spin the ship, it becomes necessary to work the button too fast for comfort, and it is difficult, to say the least, to proportion the on and off time to keep a steady course.

It is evident that some form of mechanical pulser with provisions for varying the on-off proportion is a necessity. There are two types that have been used and details of their construction will be given in the next article. You might, of course, develop a different form that more nearly fits the materials you have around the shop.

The only function of the pulser is to key the transmitter on and off rapidly, and to provide a means for you to vary the proportion of on- to off-time. One extreme of the control would keep the signal keyed on all the time, the other extreme would keep it off all the time, corresponding to full right rudder and full left rudder respectively. If the control were held in a position, say one third from the left extreme position, the rudder on the ship would be turned left two thirds of the time, and right one third of the time. The net effect on the plane by **GEORGE E. TRAMMELL**

would then be a third of full left rudder because the amount of time the rudder was turned right would counteract the same amount of time from the left rudder. If the control is held in the center position, the signal would be keyed on half the time and off half the time, to give us right half of the time and left half of the time, resulting in no effective rudder. From this we see that the amount of effective rudder is proportional to the position of the manual control on the pulser. The fact that the rudder is snapping back and forth all the time is of no consequence, as it is happening too fast for the ship to follow anything but the average position.

A geared electric motor was installed to actuate the rudder on the first model. This does not work out the way one might imagine at first. The motor with gear train is too slow to follow the pulsing; when the control is moved slightly off to one side, the motor will gradually creep in that direction, causing the ship to get more and more rudder. If the control is now centered the rudder does not return to neutral but only wavers slightly, remaining in the same position it had reached before the control was centered. It was found necessary to give opposite rudder until the control surface reached neutral, then neutralize the control. While it is possible to control a model pretty handily this way, it was not quick enough to fulfill the writer's requirements.

After much thought on the subject, along with some reading, an *actuator* similar in principle to the present one was designed, and after several were built, one was efficient enough to try. The very first flight proved it to be just what the doctor ordered. Several similar ones were built with varying degrees of success, then came the long silent period.

The July, 1947, issue of M.A.N. carried the article giving drawings and a brief description of these *actuators,* and of the pulse system. Since that time the system has remained the same, but the *actuators* have been improved and simplified.

Experiments along several lines of thought have not proved as successful as the old system, so it looks as though the writer is sticking with it a little longer—at least until someone can show up with a system offering advantages not to be found in any other that is currently popular.

Now, let's take a look at the drawings and get down to the details of building one, or both types of *actuators.* You might wish to try one in place of your escapement, controlling with a push-button as mentioned earlier, before building the pulser ground control.

The straight solenoid, or push-pull type, shown in Fig. 1 may be found somewhat simpler to build, if it fits the material you find handy. The rotary type, Fig. 2, has several advantages, even if there is a little more work to constructing it. Let's look at a couple of its advantages: first, it has a more even power stroke. When linked to a long control horn on the rudder from a very short arm on the *actuator*, the leverage increases toward the ends of the stroke; this is just what we need, since the pressure builds up on the rudder as it is moved further off-center. Second, it is inherently balanced so that it doesn't give you more of one rudder position in a climb, and more of the opposite in a dive. This, of course, is of no consequence if you do not intend getting this ship into stunting attitudes.

Here is a detailed description of the construction of the solenoid type. The armature is made of two pieces of alnico bar. You may use either flat or round bar with equal results, but the round stock is easier to work with.

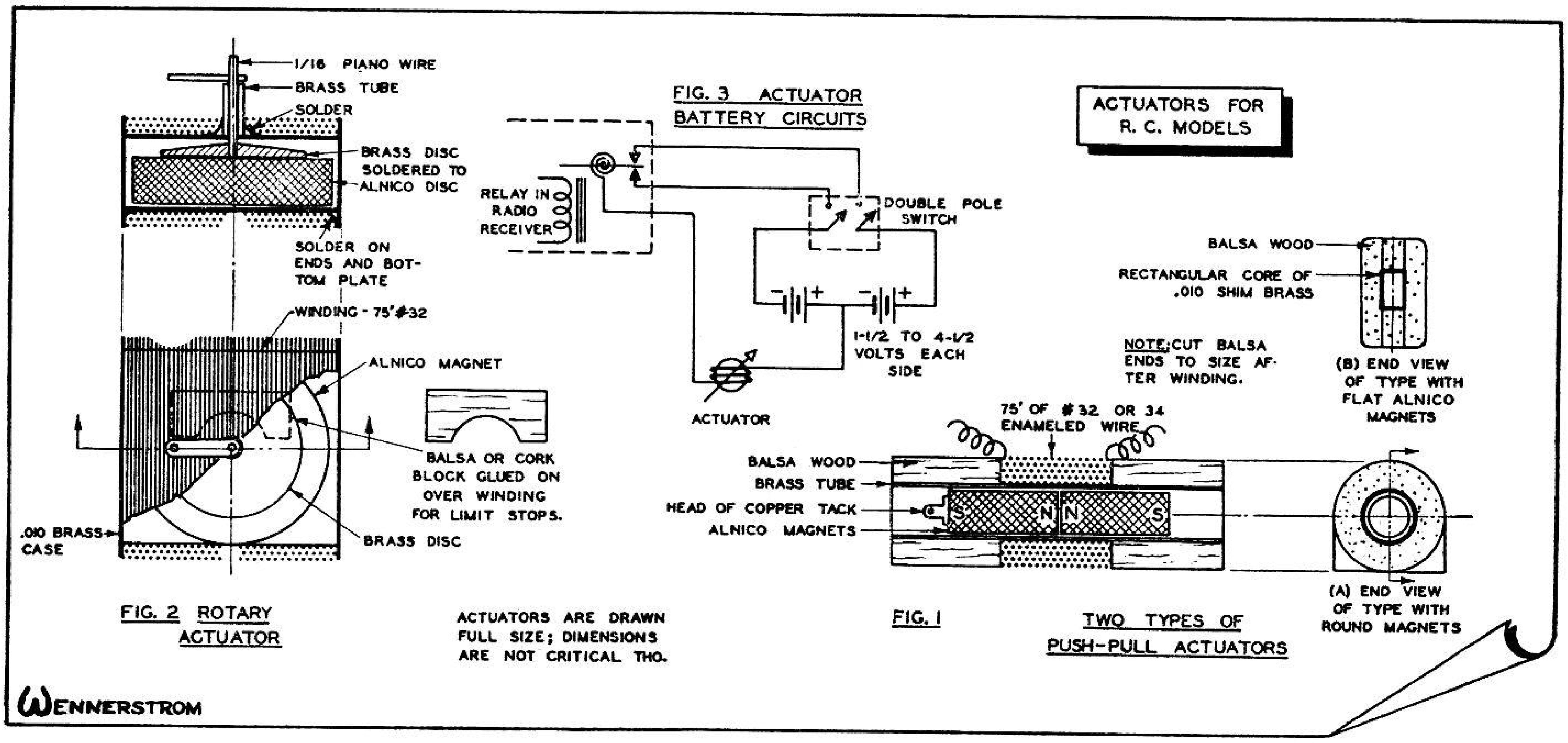
There are some "ships compass compensating magnets" on the surplus market. These are 1/4" alnico rods about 4" long, ground smooth and then lacquered. This saves a lot of work on the polishing as all that is needed is a little glow fuel or acetate to rub off the lacquer. If you do not have the luck to find one of these rods, and get hold of some rough cast material instead, you are in for some work grinding the entire surface smooth and polished, for the magnet must slide freely in the brass tube.

If you have the long bar, put one end in the vise with about 3/4" projecting; a light tap with a hammer will neatly break the bar off. Repeat the operation as we will need two magnets. Next grind the ends true, and make both exactly the same length.

A soft wheel of 60 or 80 grit is best for grinding this hard material. If there is no facility for keeping the grinding wheel wet, the little bars will have to be dipped in water frequently to keep from burning your fingers.

The next step is to solder the magnets together, end to end. They must have like poles together; this is the direction in which the two pieces repel each other, or jump apart, if released. You will need a block with a groove in which to place the pieces while soldering, so they will be lined up as a straight bar. Put a stop in the groove to push one end of the bar against, as you will have to push them together while soldering, and hold them this way while they are cooling.

A few words about soldering this uncooperative material might be in order. First, a good acid flux is a must. There is one on the market known as "Ruby Fluid" which works fine. Most welding or sheet metal shops have this or a similar flux for soldering stainless steel. There may be other suitable fluxes but this one we know works. Place the pieces in the vise with one end sticking up above the jaws. Use a piece of cardboard on each side of the bars so the heat will not be lost in the vise. Place a drop of acid on the ends and smear it around to cover the entire surface. Have the soldering iron good and hot and well tinned with solder. Touch just a little solder to the tip and immediately place the tip squarely on the end of one of the alnico bars and hold it there a few moments. When the iron is lifted, the solder should appear as a thin shining liquid. If the solder has a grainy texture, it is a sign the iron is too small or not hot enough. Most 100-Watt electric irons are hot enough for the job. If the solder did not adhere in some spots, put on more acid and apply the heat again, but if the surface develops any dark spots it will be necessary to grind a new bright surface and start over (*Turn to page* 54)



Simple Proportional Control

(*Continued from page* 25)

again. Turn one of the pieces over and tin the other end too.

After the pieces are completely covered with a thin coat of solder on the ends place them in the grooved block you have prepared. Be sure they have *like poles* together. Wipe the tip of your iron clean and put on some fresh solder, then apply the tip across the junction of the two bars. Don't be impatient, hold it there till the solder squeezes out as the two magnets are pressed together. Remove the iron but hold the magnets firmly together till they cool.

Solder an eye on the other tinned end to receive the push-rod; a copper tack is fine for this purpose. Mash the shank in the vise a little to make it wide enough for the hole, then cut off the surplus length. Tin the head of the tack, and solder it to the magnet.

Scrape off all surplus solder with a knife. Solder on the double magnet will cause a lot of friction against the brass tube it is to work in.

From a thin brass sheet about .008 or .010" thick, form a tube around a rod just a few thousandths of an inch larger in diameter than your double magnet. Make the tube three times as long as *one* of the individual magnets.

Fit balsa blocks over the tube to leave a winding space in the center the same length as one individual magnet. Insulate this space with thin paper or cellophane tape, then wind on 75 to a 100' of #32 (or 60 to 75' of #34) enameled wire. This will give a drain of less than 1/4A on 3 volts.

As seen from the circuit diagram, this arrangement requires two batteries in series, but only one is in use at a time. This gives the batteries half time on and half time off, which lengthens their life considerably. For light ships only one pen cell is needed in each battery. If more power is required, two or even three cells may be connected in series for each side.

The rotary-type *actuator* requires only slightly more work to build. The principal difficulty is in procuring the proper size alnico disc which is magnetized across its diameter. There are some little electric outboard motor boats on the market which have a dandy alnico disc in the motor. There are some 1-3/32" discs on the surplus market, but that is a bit heavier than needed, making up to a finished weight of close to 2 oz.

Whatever disc you use, make sure it is magnetized *across* the diameter, and has only one North and one South pole. (Some disc magnets are available with two, or even more, North and South poles.) Suitable magnets, 3/4" diameter x 1/4" thick, may be had from R. Eyrich, 2566 North Forty-ninth Street, Milwaukee 10, Wisconsin. They sell at four for a dollar.

The disc can also be ground from a square block; in this case and also in the case of the 3/4" discs mentioned above, there is no hole to slide the shaft through, so a brass disc is soldered to one face of the alnico, with a tight fitting hole for the shaft. The brass disc should be as thin as is consistent with good strength, because the closer we can keep the winding to the alnico armature, the stronger the pull of the *actuator* will be. If you decide to grind down an alnico block, don't be surprised if the alnico wears the grinding wheel pretty fast as it is really hard stuff. It takes about 30 mins. of grinding to shape a 1/4" x 7/8" sq. block into a disc, and face one side for soldering. Other details of the rotary *actuator* are shown on the drawings. Keep it light, be sure the armature turns freely without scraping at any point, and make your soldered joints firm.

Now a word about the rudder on the ship. It has been found that a tall narrow rudder will require less power to move than will a wide one of the same area. On most 6' ships a rudder 1" wide and 5 or 6" tail will prove adequate, when turned a maximum of a 1/4" off center measured at the trailing edge.

Sometimes the movement of the rudder is hardly noticeable when the pulser motor is running, yet in the air it will turn the ship sharply. But be sure the movement is quite free; the rudder should slap back and forth sharply when the transmitter is keyed on and off.

If you want enough rudder action to really cut up, the surface should be of the counter-balanced type, as it is on many big planes. Either overhang ahead of the hinge at the top, or a hinge line set back about 20% on the rudder is effective.

Put a control horn on the rudder of such length that the *actuator* moves the rudder only about half an inch or less, for a full *actuator* stroke. The horn is conveniently made of about #18 soft wire with a small eye bent at the end to receive the push rod. After you see how much rudder the ship will stand, the horn may be shortened by bending a kink or two in it to increase the rudder movement.

Put stops on the *actuator* just short of the full stroke or it will not return from the end of the stroke without the air blowing on the rudder. It is a great comfort to see the rudder wiggling back and forth as the ship is released. If you don't know how much rudder your plane will stand, be sure to keep these stops set in very close for the first flight. Lots of ships have been wrecked from too much rudder, but mighty few have been lost from too little.

Next month we will take up the construction of the ground control unit, or pulser, and also the pulse rate control which can be added to the pulse proportion rudder control. This second control working off the same radio set in the plane may be operated on or off without affecting the rudder control. This control may be connected to the throttle or the elevators, or any second control in the plane you wish to operate. The pulse rate control will add only about 5 oz. to the weight of the plane.

RADIO CONTROL FANS

We have printed dozens of R. C. articles in past issues; if you do not have a file of these copies, send for our free list of R. C. articles.