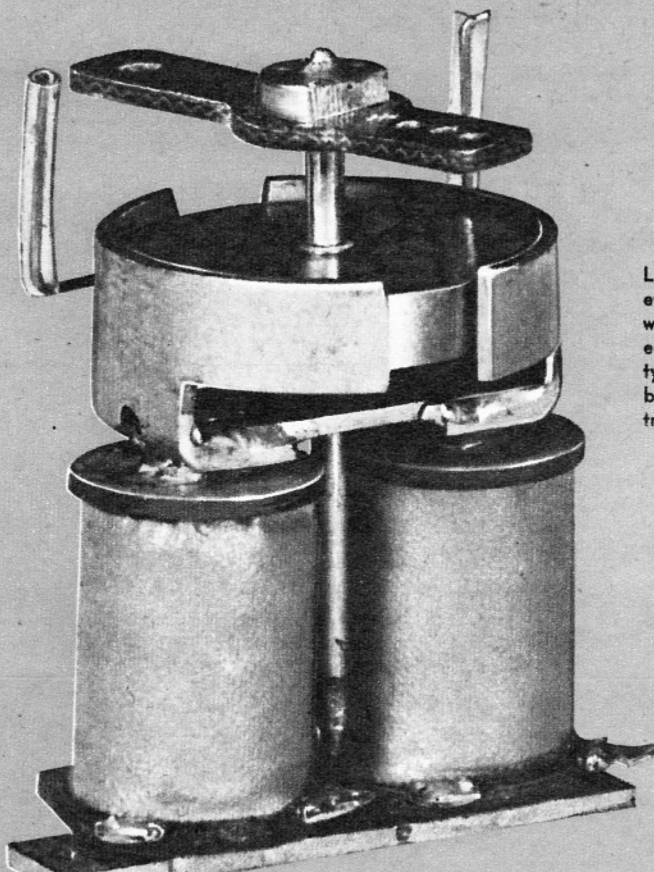
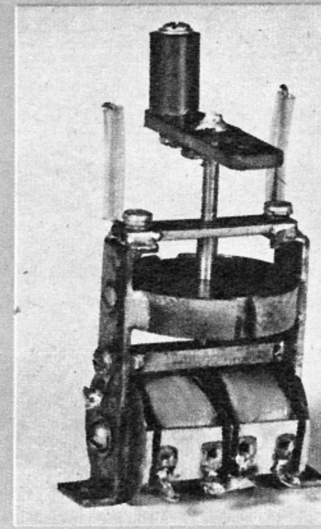




Latest version (left) has more efficient coil design, is somewhat more compact and lighter than earlier experimental type (rt.). Weight hasn't yet been attached to end of control arm (away from camera).

"Mactuator"

A MORE EFFICIENT MAGNETIC ACTUATOR FOR RADIO CONTROL

By HOWARD McENTEE, W2SI

■ There is little to add to what George Trammell had to say about proportional control in the Jan. '54 issue, and the equipment he described will give fine results. However, for some time we have wondered just how efficient the style of actuator that George showed might be, and how it compared to a heavier and more complex type we have been using. Finally, curiosity got the better of us and test equipment was set up to find out the answers.

There is no doubt at all that George's "simple design" is indeed the simplest and lightest we have seen to date which will do a decent control job. However, the design does not lend itself well to what is known to be the best form of the magnetic winding. Let's digress a moment and outline what factors affect the amount of twist you get to move the rudder—or in other words, the torque that the actuator can produce. First and foremost, of course, is the current you put through the winding. The resistance of the winding is also important, in that it settles how many volts you must have to get a certain current. Thus, a low resistance winding should give higher torque than one of higher resistance, provided the same current is put through in each case. It does, too, but there is another factor we have to consider—the number of turns.

Actually, magnetically operated devices depend for the power they can put out on the "ampere-turns," or the product of the number of turns on the coil by the current in amperes going through them. Now to cite some figures, we have recorded: if you take a certain core and wind 700 T. of No. 30 wire on it, you will get a certain value of torque. In this case, the turns times the milliamperes (we use ma. here, as a more handy figure with which to work) is about 81, since the test coil showed a current of about 116 ma. with 1.5 V. If the coil was rewound with 600 turns, and then with 500 turns of the same wire, each time the ma.-turns would come out about the same, and the torque would be the same.

The core of this coil happened to be rather short, so the coil got pretty fat with the 700 turns. The last turns put on were of large diameter—which meant that they added a lot more resistance than turns close to the core (which were much smaller in diameter) but each outer turn had just about the same effect in producing magnetic flux in the core—which was translated to torque at the shaft—as had the small diameter inside turns. The answer to this, then, is to make the coil long and skinny, if you can; all the turns on such a coil will be relatively small in diameter, and you can get on a lot of turns before the resistance gets too high.

The actuator shown in the smaller photo is a type which has been proven to give very efficient results; it gives a lot of torque for a moderate amount of power put in. It is of the two-winding type, which is used with a single battery in the plane (see circuit drawing—note how this differs from that on P. 53 of the Jan. '54 issue). This means that we had only half the total winding space to devote to each coil. It was on this actuator that the above windings were checked; it has been used with a single 1.5 V. cell, to give plenty of rudder movement in a fairly fast 54" plane.

Pursuing the idea of a long thin coil as the ideal, we tried out the design shown in the larger photo, and in the drawings, and found that it really has it all over the earlier unit, even though the latter has a larger magnet, draws higher current, and weighs quite a bit more. It will be seen that the latest design has the long coil—in fact there are two of them, one for each direction of pull. These coils were each wound with 950 T. of No. 30 en. wire, giving about 11 ohms, and a current of about 120 ma. on 1.5 V. We have, then, a ma.-turns rating of 115, so we would conclude that this unit should be a lot better than the earlier unit.

Unfortunately we could not compare them directly; it is most difficult to compare several different actuators on any simple basis, since many other factors besides ampere-turns enter into the deal. For example, the size of the permanent magnet, how heavily it is magnetized, the spacing between magnet and polepieces (in this particular style of actuator) and so on. Despite the fact that the new unit has only a 1" x 3/16" magnet (the old one has a 1" x ¼" disc) and weighs considerably less, due to the use of thinner iron in the entire unit, it actually does show more torque than the old job. In definite figures, the new one showed a maximum of .300 inch-ounces, as against .260 for the old. Torque, incidentally, is measured in such multiple units as inch-ounces or foot-pounds; this is simply the product of the amount of pressure (measured in ounces) times the distance from the center of the shaft that the pressure is measured.

As a matter of interest, an actuator of the sort described last January, with a ¾" x 1" magnet and a winding consisting of 385 T. of No. 28 wire (which gives 220 ma. on 1.5 V.—hence an ma.-turns figure of 84.7) gave a maximum of only .115 inch-oz. torque.

We have given a lot of figures here, to try to show those readers who make their own what they might expect, or so they can learn why a given actuator does not come up to expectations. When considering the various types of these units, there is another consideration: what position should the arm have to get the most effect for moving the rudder? What we call the "simple" type (Jan. '54) gives the highest pull on the arm when it is in position (A) with the power applied to give rotation in the direction indicated. This type shows somewhat better torque over a wide range of rotation than the one described later; it had the same torque at the positions shown in (B), namely—.095 inch-oz. Hence, it could be used with a control arm which moved almost 90 degrees, to get the desired rudder movement.

The type shown in the smaller photo has a more limited movement; greatest torque comes at about the position (C)—while torque values for other arm positions are shown in (D). Thus, this one should have the arm movement limited to about 30 degrees each side of center, or even less.

One final thought before we get into construction. This concerns the matter of "centering"—that is, the tendency of the arm to return to center position when the current is cut off. This is an advantage in many respects, as it means that the rudder will tend to neutralize if something goes wrong (such as a dead actuator battery or broken lead in the actuator circuit). The "simple" type has no centering action at all; however, it is easy to make this type return towards center by just placing a very small bar magnet at the rear of the unit. By turning the magnet, the arm may be brought to exact center when no current is in the coil. You should not go too far in this matter of centering, though; it takes power from the battery to overcome the centering magnet, and furthermore it is better to have the rudder not go all the way back to neutral, should something happen during flight, for then the plane will tend to circle rather than take off in a straight line.

The "iron polepiece" actuator has an inherent centering action that depends upon many factors; the closer the gap between polepieces and the heavier the iron in the core and other parts, the *less* centering you will get. Centering may be increased by putting a slight airgap in the core, such as at point X under "Polepiece Assembly." Just insert a thickness or two of paper. However, this action will cut the available power a small amount.

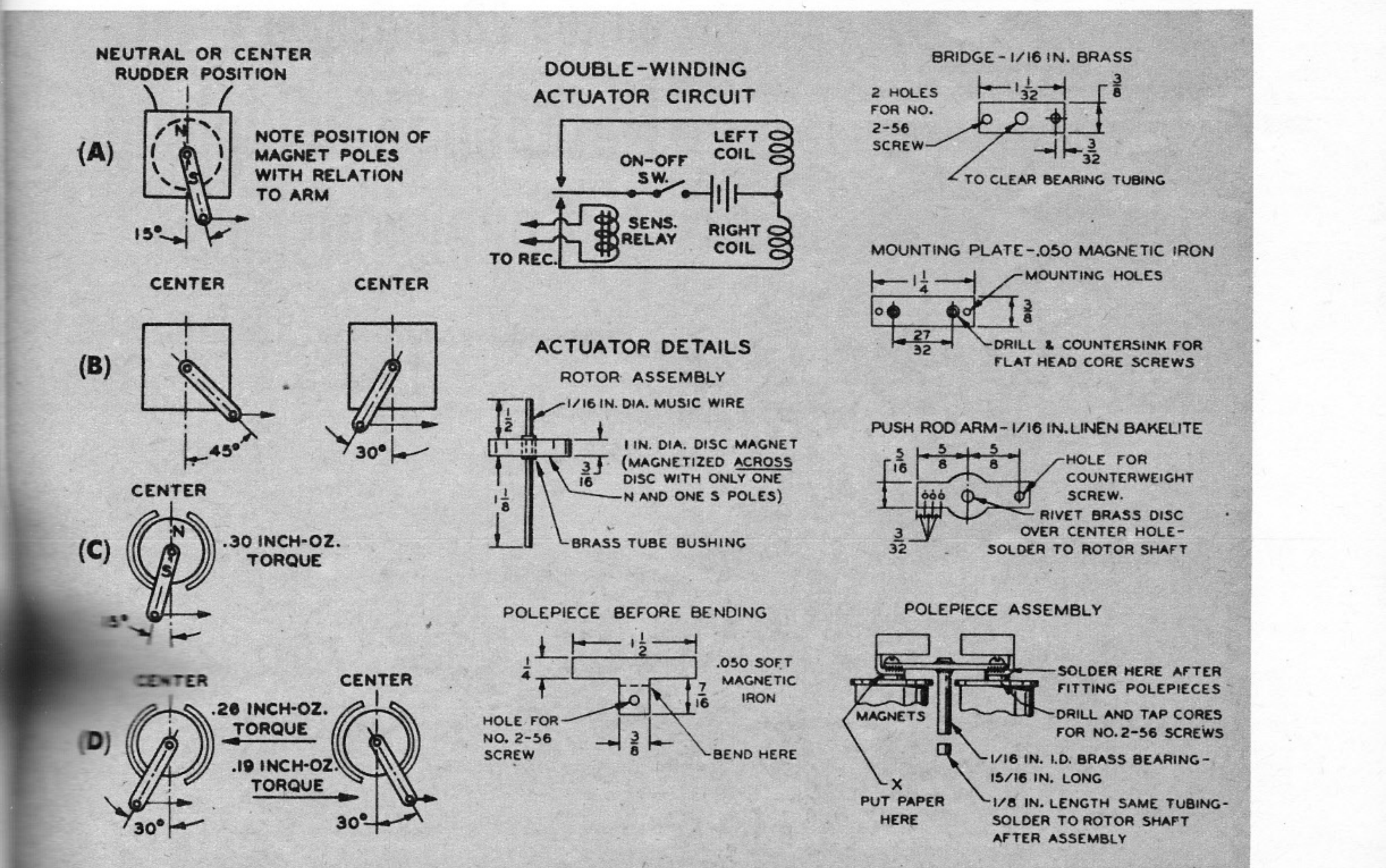
The unit shown under "Actuator Details" was made from iron salvaged from old relays. The iron used in actuators should be a good magnetic grade; plain cold rolled steel will work, but true magnetic soft iron is much better, and defunct relays and other magnetic devices are a good source. (Some of the R/C suppliers sell magnetic iron in small quantities at low prices.)

The first step is to mount the magnet on its shaft, making sure it doesn't wobble as the shaft is turned. The magnet specified has a ⅛" center hole; a piece of brass tubing was found that would fit this hole and had a 1/16" hole for the music wire shaft. The whole assembly was fastened together with solder, using a bit of acid flux.

The polepieces are cut from flat stock, then bent around a 1"-diameter rod. After they are bent to fit around the magnet—with a clearance of 1/64 to 1/32" all around—the lower end of the "T" is bent inwards and drilled.

The bridge (of brass, *not* iron!) should be made a trifle long—about a thirty-second at each end. Drill the center hole and solder in the bearing tube. Then drop the rotor in place and trim the ends down till the polepieces have the proper clearance. When they do, fasten them to the bridge temporarily with nuts and bolts, and solder this assembly together.

The coils were wound on bobbins taken from commercial (*Continued on page* 69)



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(*Continued from page* 43)

magnetic units. None could be found with the correct windings, so the original wire was cut out, and the cores rewound. Before winding, the cores were drilled and tapped so that screws could be put in from each end. Winding was accomplished by clamping a hand drill in a vise, with the bobbin held in the chuck by means of a screw with the head clipped off. Each one required only a few minutes to wind, and care was taken to make the winding as smooth as possible—that is, in even layers.

The last framework piece to make is the mounting plate, which, since it is also part of the magnetic circuit, must also be of good iron. It is tapped for two mounting screws.

A couple of music wire stops were soldered to the polepieces, and rubber tubing slipped over them, to act as stops. The arm is fitted with a brass center, drilled for the rotor shaft. As we have had trouble in the past with "electrical noise" made by the rudder pushrod rubbing in a metal actuator arm, we always fit an insulating arm of this sort. To get the arm in the correct position on the shaft, remove the mounting plate, to allow the rotor to center strongly; then solder the arm fast with the ends extending across the gaps in the polepieces.

The actuator described is intended for use on 1.5 V. and should handle a plane up to about 5′ size. For more power, you can use 3 V., or you could put on a winding of about 1300 turns of No. 32, which will give lots of pull on 3 V., but lower current.

It will be noted that the arm is double-sided, with the long end marked for a "counterweight." When the actuator is installed in the plane, and hooked to the rudder, a weight is fastened to this end of the arm which will just balance the