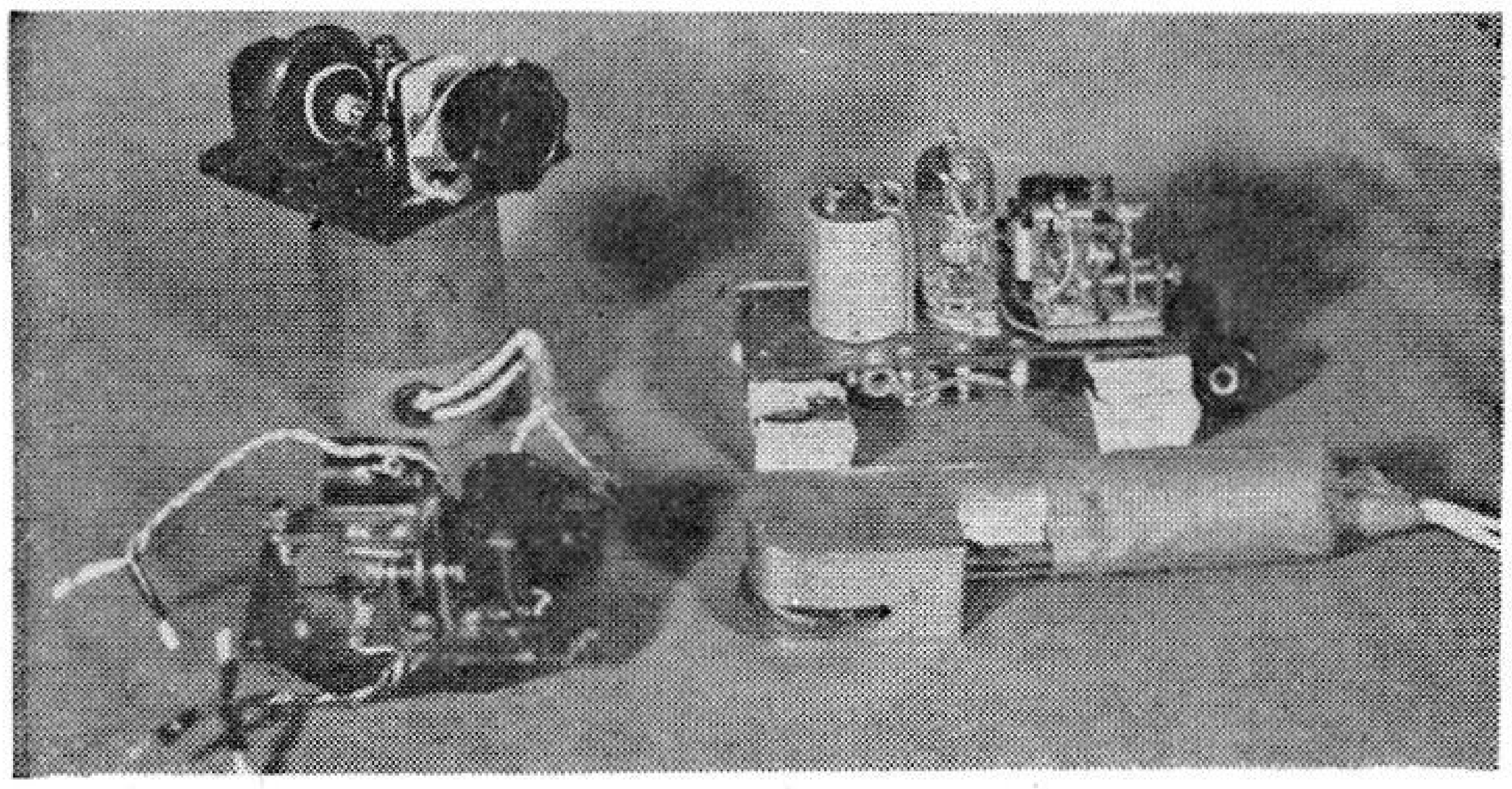
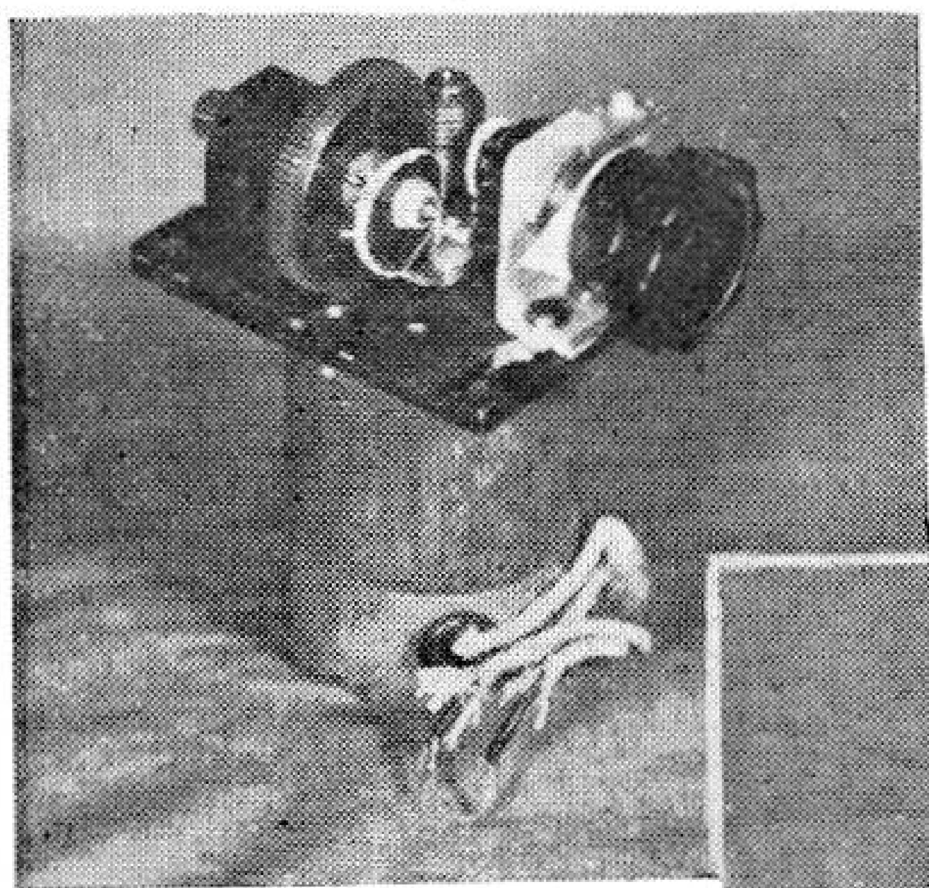
simple proportional control

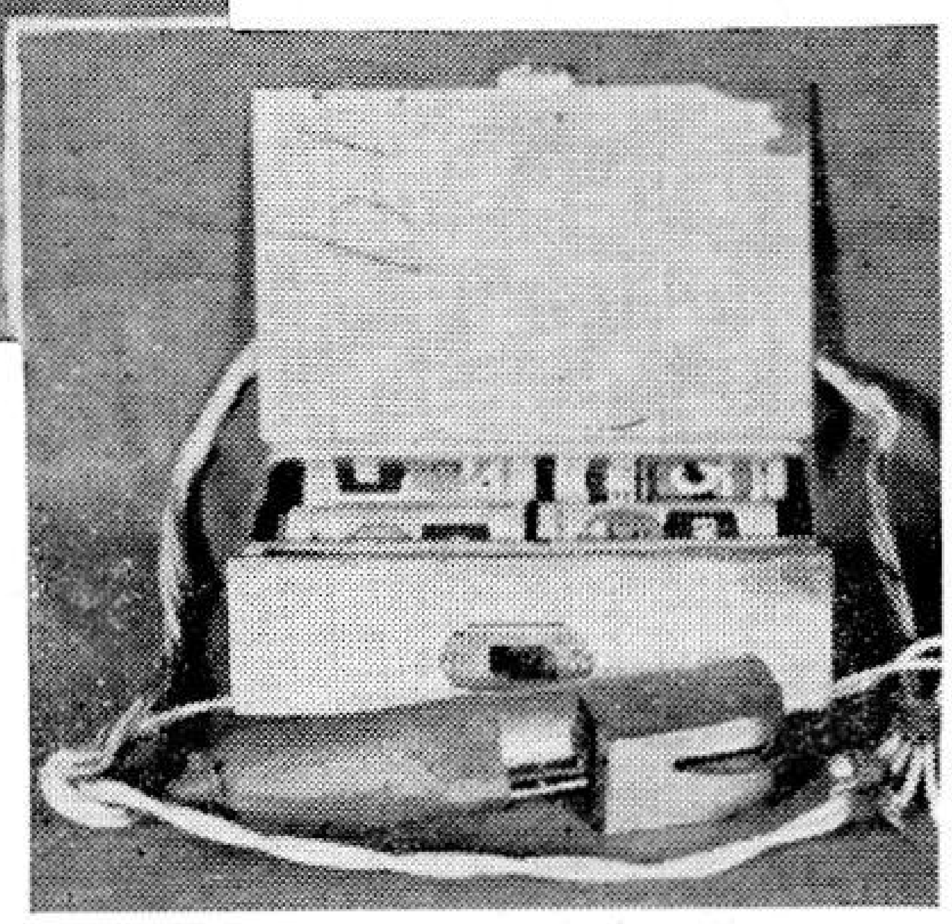
PART TWO



Above. Several control units; at upper left and lower right are pulsing units. Other items are assemblies for pulse rate control



At left, simple pulsing unit shown in drawing on page 24



Right, miniature pulser with box of cells which hangs on belt

Below. The author gets ready to fly his latest R.C. ship

by GEORGE E. TRAMMELL

LAST month we covered the reasons for using pulse control on R.C. models, the primary reason being that we can get proportional control; the amount of control the model receives is proportional to the movement the pilot gives with his control stick. Either gentle or tight turns may be executed at the will of the pilot. The next reason is simplicity and reliability. Also it is possible to add another control which may be operated on the same radio but independently of the first. This extra control operates by varying the pulse rate; it is either on or off at will, and is well suited for operating the throttle.

The construction of the control *actuators* developed by the writer were covered in the last issue. This month we will take up construction of the pulsing unit, which is the pilot's control. Also the pulse rate unit and wiring diagrams will be explained.

While it is quite possible to use an electronic system to produce the pulses, it has worked out much cheaper and easier to build a mechanical pulsing control. Therefore we will confine this description to the latter.

The main requirement of the pulsing unit is that the transmitter keying contacts in the unit must be varied by the pilot's control stick. While the motor driven cam speed governs the *rate* of make and break, the pilot's control stick governs what proportion of the time the contacts will be closed or open; the proportion of on- to off-time of the transmitter is therefore controlled by the stick. When the stick is in the center, or at neutral, the contacts should be closed for half a turn of the cam, and open the other half turn. As the stick is moved right, the contacts should stay *closed* a greater proportion of the time; when it is moved left, they should stay *open* a greater proportion of the time. The extreme limits of the control stick movement should be barely sufficient to keep the contacts closed or open all the time.

An electric motor and gear train are arranged to turn a cam at a maximum speed of about 600 rpm, or 10 turns per sec. Against this cam rides a hinged arm carrying one of the transmitter keying contacts. The other keying contact is so arranged that it is moved by the control stick. It is important that the cam on the control stick have just enough throw to hold the contacts together when in its extreme right position, that is—the motor driven cam will barely miss the contact arm. Of course, in its extreme left position, the contact arm should ride the motor cam for its complete revolution without the contacts quite making.

Referring to the drawing in Fig. 1, we see one of the simplest forms of pulsing unit. The motor and gears were picked up at the local junk yard. Although the motor is rated at 27 v. DC, it was found to run at about the right speed on 6 v. The contacts were taken from an old telephone-type relay, although pieces cut from spring brass or bronze would do as well. The contact arms are insulated from each other by a stack of sheet fibre.

Fig. 2 shows a compact little job, which was built by the writer's brother, Mark. He used a *Rev Motor* or *Electrotor*, and a worm and gear from an electric clock. The contacts are ignition points that came off his *K & B Torp* when it was converted to glow operation. The bearings and shafts are brass tubing and piano wire from the local hobby shop, and the case is fuel tank material from the same source. He uses a box, containing four large flashlight batteries, clipped to his belt to power the motor in this pulsing unit.

These two control units so far have no provision for changing the pulse rate to operate the second control. If your motor and gears work out to something like nine or ten revolutions a second, a rheostat may be used to reduce the speed to about a third this rate for the slow pulse rate. By connecting a push-button or a switch across the rheostat, the speed, and consequently the pulse rate, can be changed with only a slight delay.

Because of this delay while the motor is changing speed, and the fact that some motors don't run very steadily on reduced voltage, it has been found preferable to change the pulse rate by another method. Referring to Fig. 3, there is a single lobe cam and a three lobe cam on the same shaft. Each cam has a separate contact arm riding on it. The contact arms which are moved by the control stick are made as a single wide arm with a contact to match each of the contacts on the two arms which ride the cams. A single pole double throw switch connects the transmitter keying line to one or the other of the sets of contacts. One of the photographs shows a two-channel double cam control box which the writer has used for

(*Turn to page* 60)

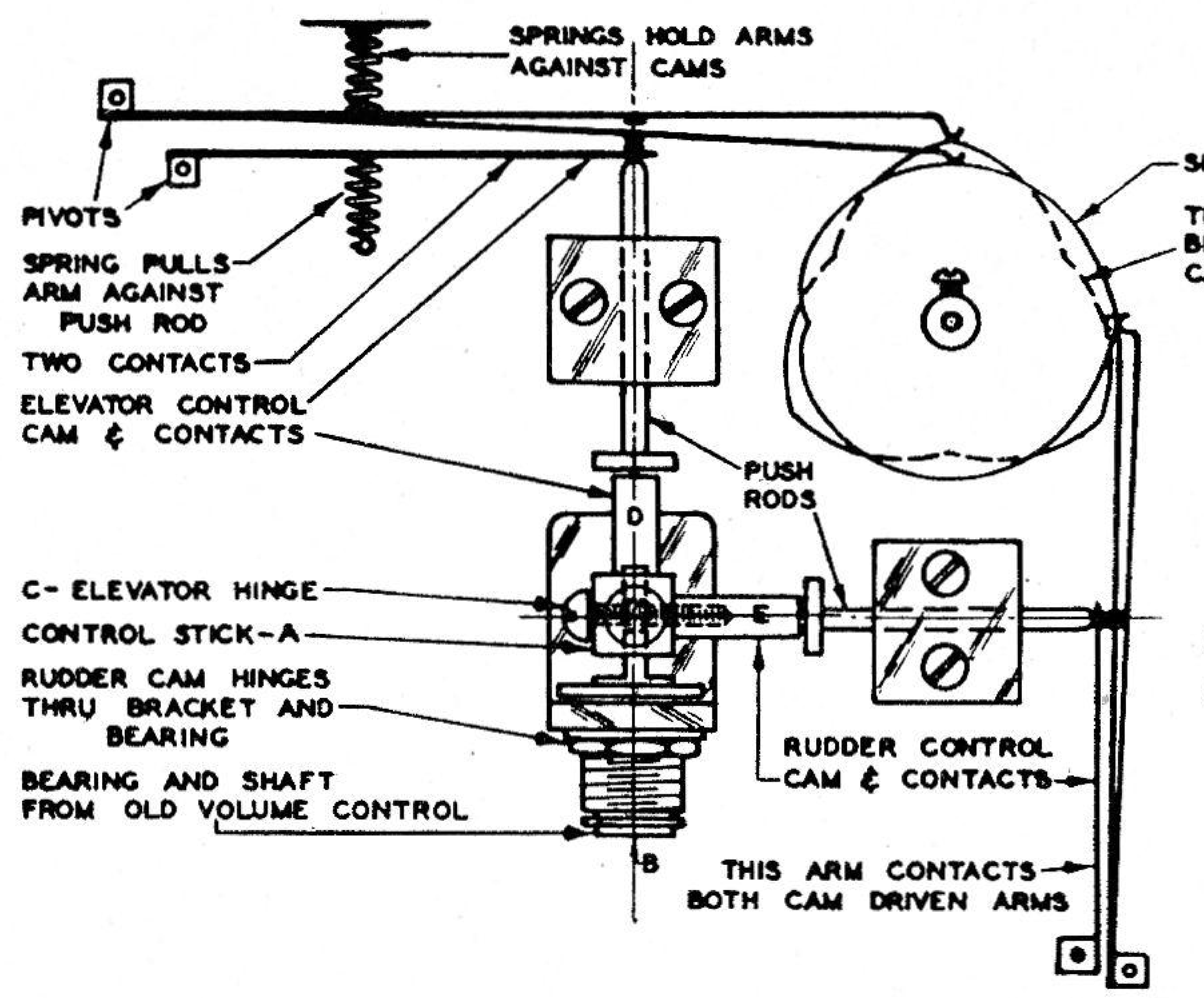
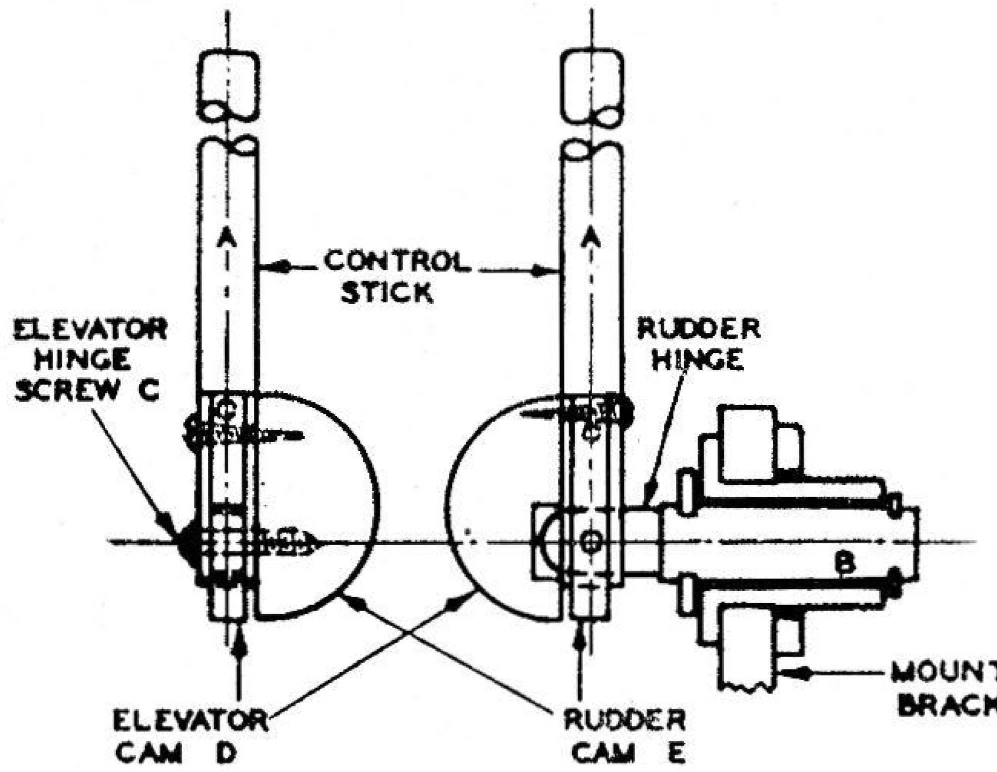


FIG. 3 - CONTROL UNIT FOR TWO CHANNELS
TWO SPEEDS OF PULSE RATE ON EACH CHANNEL



CONTROL STICK DETAILS

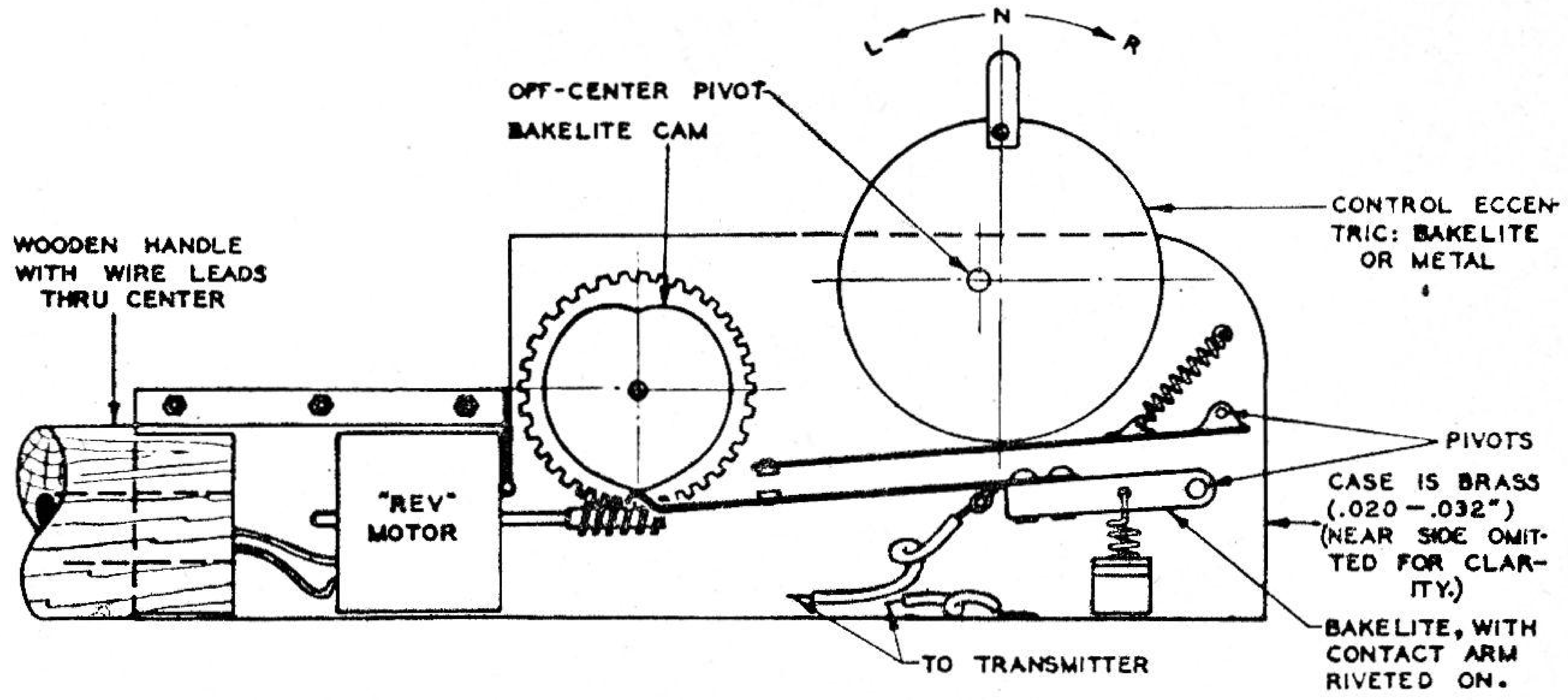
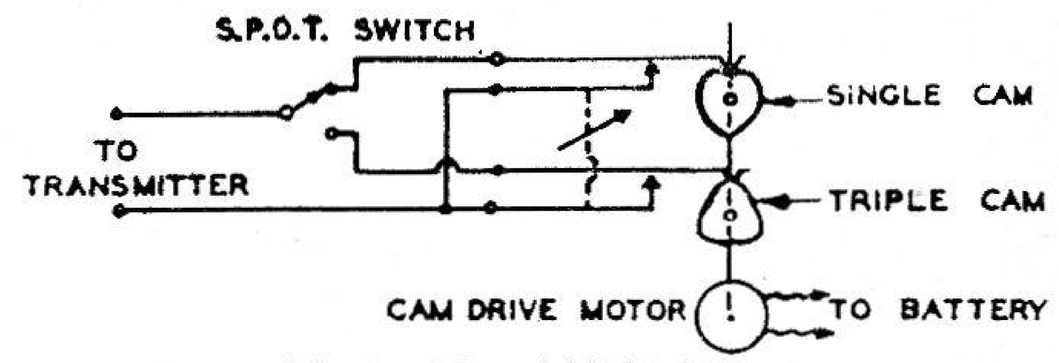
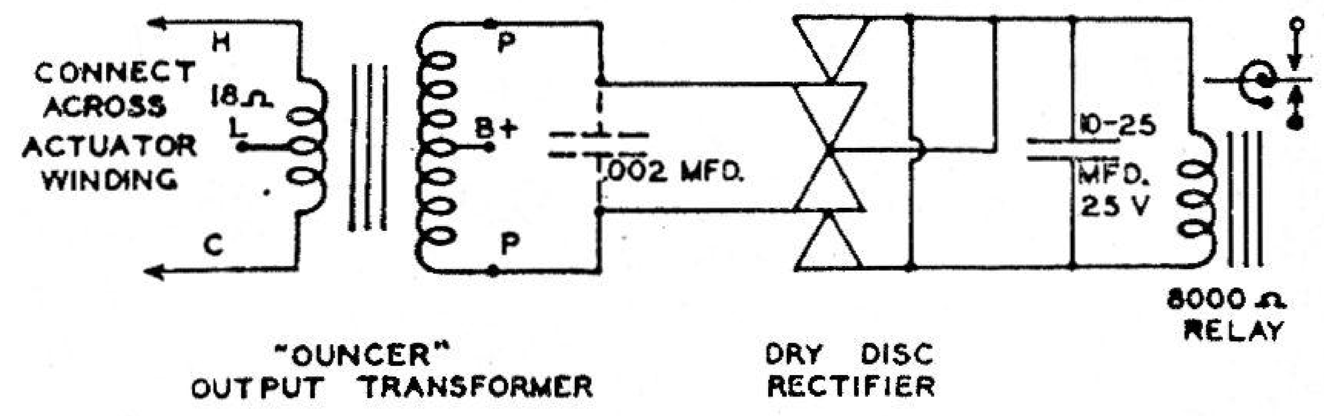


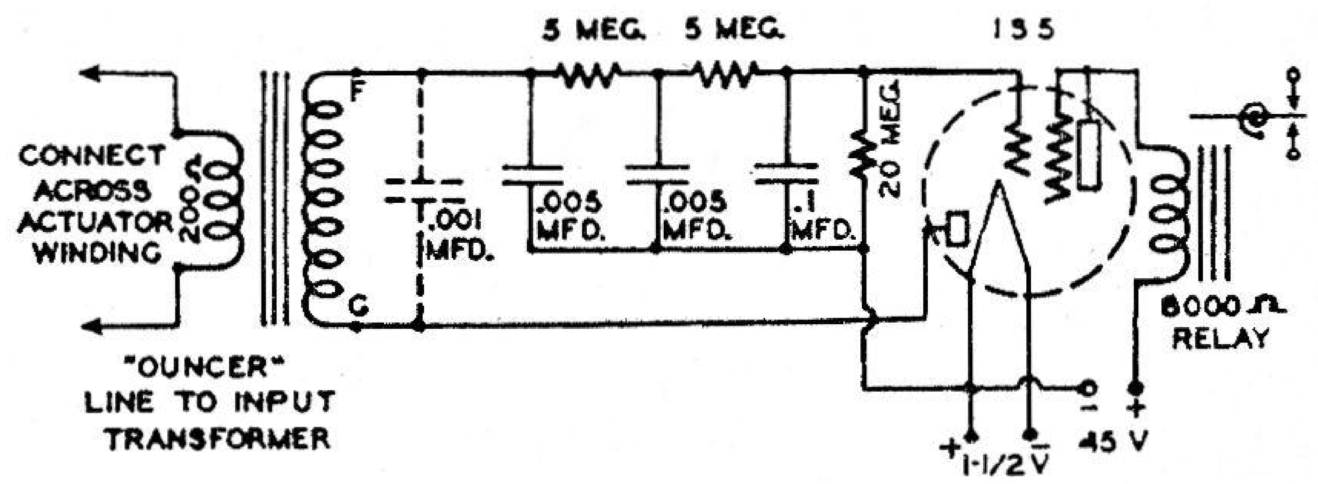
FIG. 2 - PULSE CONTROL UNIT
BUILT BY MARK TRAMMELL



PULSE RATE CONTROL
UNIT CIRCUIT



PULSE RATE CONTROL UNIT
USING COPPER-OXIDE RECTIFIER



PULSE RATE CONTROL UNIT
USING VACUUM TUBE RECTIFIER AND AMPLIFIER

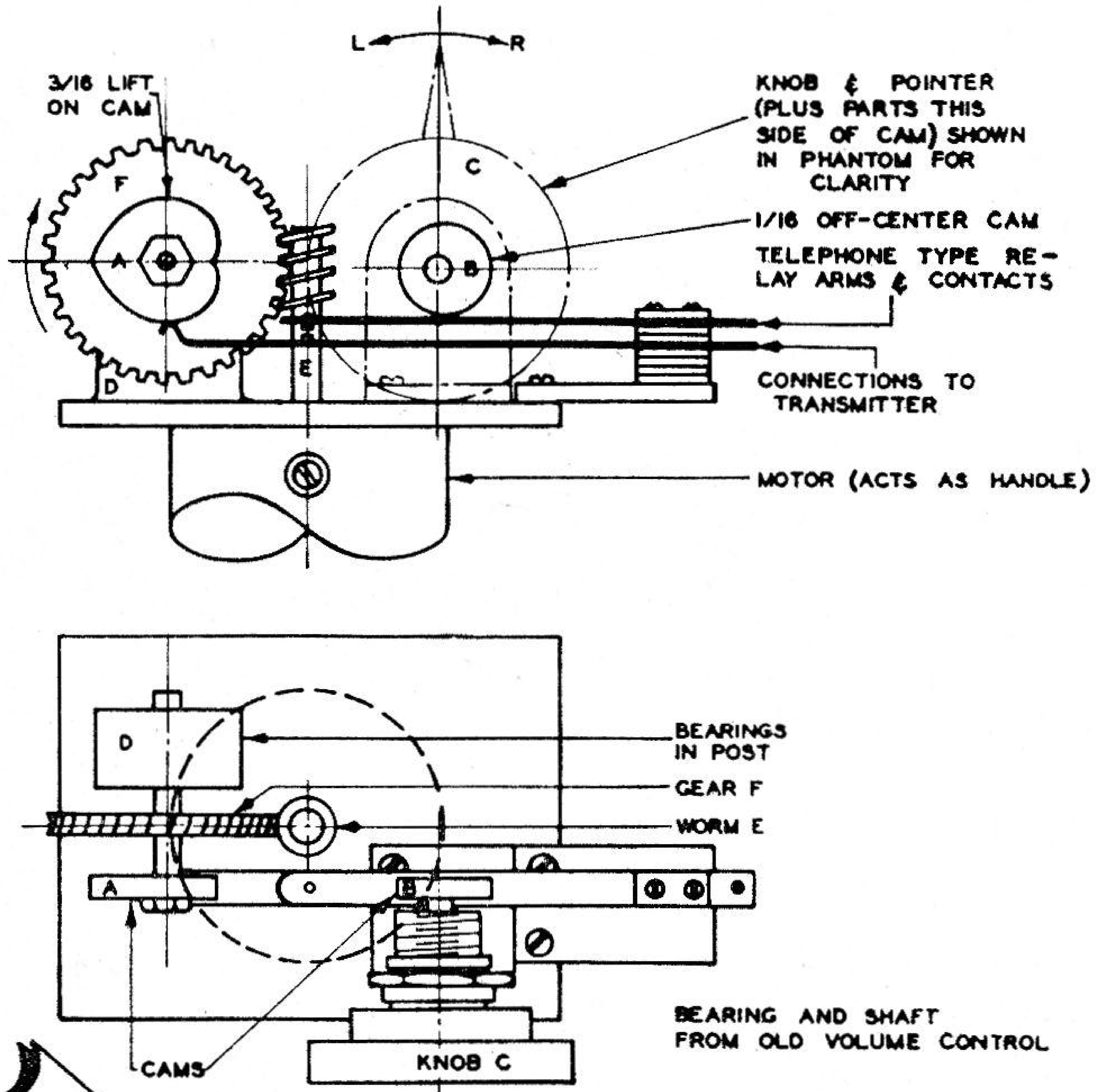


FIG. 1 - SIMPLE PULSE CONTROL UNIT

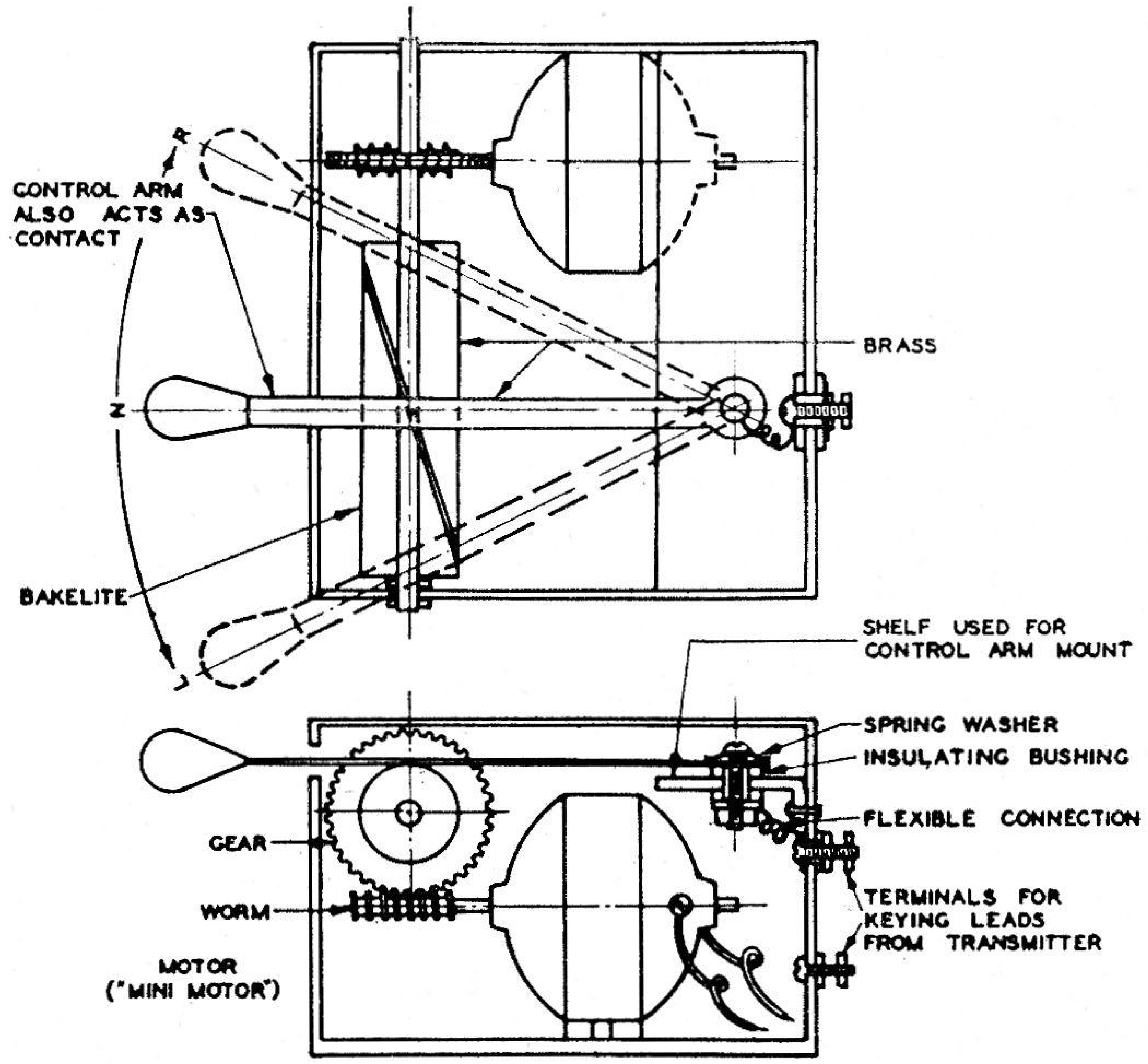


FIG. 4 - ANOTHER FORM OF SIMPLE PULSE CONTROL UNIT

AIR AGE INC., 551 FIFTH AVE., NEW YORK 17, N.Y.	
SCALE: NONE	NOTES BY MARK TRAMMELL ON SEVERAL TYPES OF
DATE:	PULSE CONTROL UNITS
DRAWN BY ... WENNERSTROM	FOR RADIO CONTROL MODELS

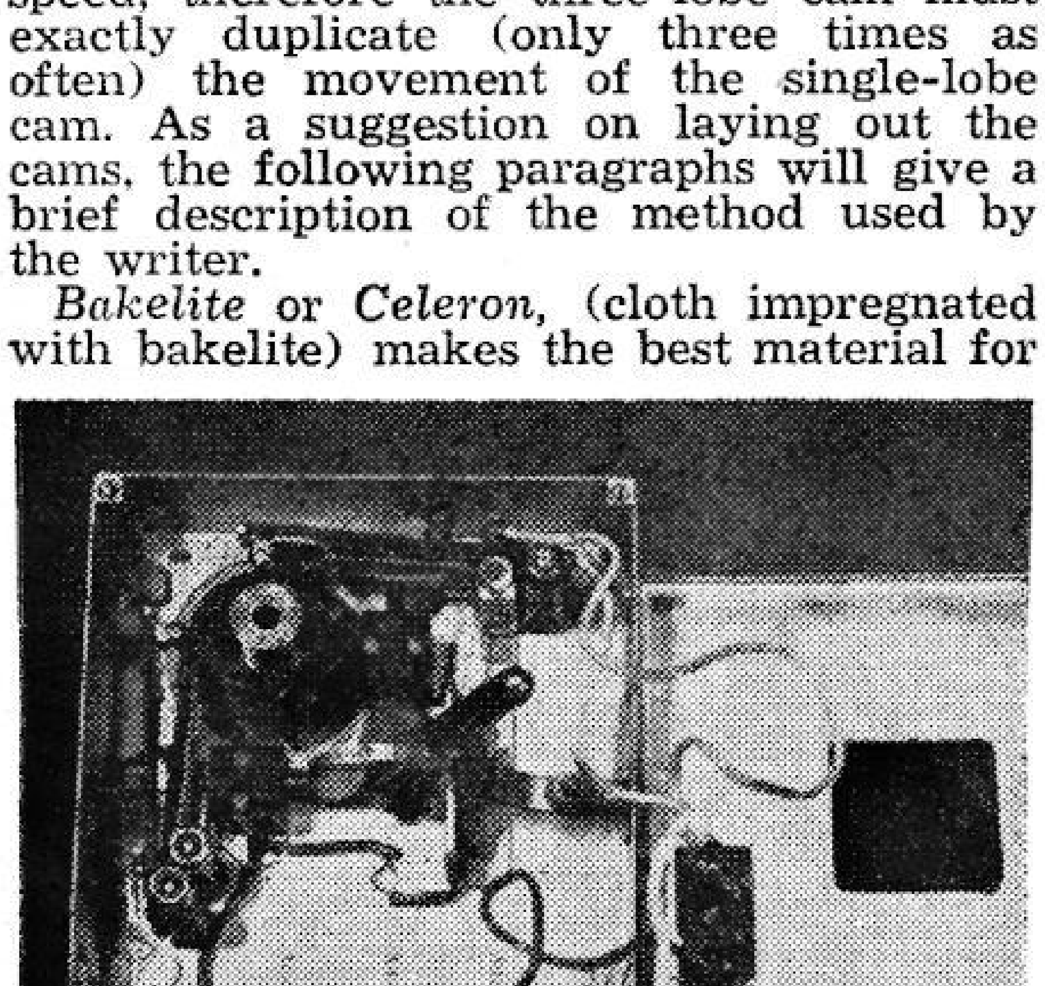
Simple Proportional Control

(*Continued from page* 23)

several years to control rudder, elevator and throttle. The fourth possible control has not been utilized so far.

Perhaps a few words on the shape of the motor-driven cams may be helpful. If round off-center discs are used, the neutral will be nice and broad but there will be a lot of control crowded up in the last few degrees of the movement of your control stick. The *constant rate* cam, which is heart-shaped, will smooth out the degree of control so there will be no crowding, or critical spots near the ends of the stick movement. How are you going to develop a three-lobe cam which duplicates the movement of an off-center disc? We don't want the rudder to change when we shift pulse speed, therefore the three-lobe cam must exactly duplicate (only three times as often) the movement of the single-lobe cam. As a suggestion on laying out the cams, the following paragraphs will give a brief description of the method used by the writer.

Bakelite or *Celeron,* (cloth impregnated with bakelite) makes the best material for the cams. It should be 1/8″ or more thick, depending upon how you intend to fasten it on the shaft.



Here is the control box for two channels and two pulse rates

A constant-rate cam is one which has a steady increase or decrease in its lift. If you wind a string around the shaft, pass an ice-pick thru a loop at the end of the string, then scribe part of a circle (keeping the string tight,) the scribed line will have a constant rate of progression, toward or away from the center, according to whether the string is winding or unwinding. If we want a 3/16″ rise in half a revolution, we would select a 1/8″ shaft, as the circumference of the shaft would be approximately 3/8″, and half a turn would give us the 3/16″ movement. To lay out the three lobes, just use a bushing around the shaft to make it three times as large; in this case the bushing should be 3/8″ dia., as this will give a 3/16″ rise in one-sixth of a circle. When finishing up the cams with a file be sure all peaks are exactly the same height from center. A look at the bobbin winder cam on the sewing machine will give you a good idea of how the single-lobe cam should look.

Another type of construction employed on an early pulse control, but not illustrated here, was an oscillating cam. This was made from an old electric windshield wiper motor and gear unit.

Fig. 4 shows still another possible style of pulsing control construction. One was started especially for this article, but was not completed in time to photograph. The rotor is made from pieces of bakelite rod and brass rod of the same diameter. After drilling the shaft hole in both rods, they were sawed at an angle as shown, and filed to fit together when pushed on the shaft. One electrical connection is made to the shaft, the other to the control arm.

The drawings all show worm-gear drives; although this is not essential, worm reductions are usually more compact than a gear train. Model electric train motor should be a good source of power for the pulser.

Now for the *pulse rate* control. Let's consider the ignition system of a gas engine for a moment. No matter how long or how short a time the breaker points are closed, we get a spark only at the instant the points open. The reason for this is that the magnetic flux (or lines of force) built up in the spark coil collapses very rapidly when the battery circuit is suddenly opened. As the collapsing lines of force cut across the many turns of the secondary coil, a very high voltage is generated. While there is some voltage generated by the building-up of these lines of force when the contact points close again, this voltage is nowhere near as high. Each time there is a make or a break in the primary circuit, there is a definite amount of power imparted to the secondary circuit; this is independent of the length of time between the make and break. Therefore, in our *pulse rate* unit, the voltage stored in the condenser is proportional to the number of makes and breaks per sec. As the pulse rate is increased, the voltage increases until finally the relay is pulled closed; as the rate is decreased the voltage falls, and somewhere down the line the relay has insufficient voltage to hold, and it drops open.

The *pulse rate* unit using the copper-oxide or selenium rectifier is more simple than the unit using a tube, but requires considerably more power from the *actuator* batteries. The unit using the tube gives a much greater change in current through the relay coil as well as a greater maximum current. The example pictured gives a current change of 0.1 ma. to 2 ma. on the same pulse rates that give 0.2 ma. to 0.7 ma. with the copper-oxide rectifier. A unit was tried using a pair of 1N34 crystals as a full-wave rectifier. The center tap of the transformer was used as the negative, and one 1N34 was connected from each side of the winding to the positive output. This works even more efficiently than the dry disc rectifier, but it is uncertain how long the 1N34's will stand up.

The copper-oxide rectifiers used here are rated 20 ma. and 80 V. maximum, although 10 ma., 20 V. rectifiers have been used with satisfactory results.

The condensers across the secondaries of the transformers, shown dotted, were found necessary when using spark ignition on the motor.

The *Ouncer* transformers we wanted to use are quite expensive, so the writer purchased several BC347 Inter-phone Amplifiers for the price of one *Ouncer.* (Watch those surplus ads.) There are two transformers in each amplifier.

The 0.1 mfd. condenser in the tube unit, and the 25 mfd. in the other unit may be reduced in capacity to cut the operating time until a point is reached where the relay chatters. The values given were found to be optimum.

You are sure to run into trouble if you try to run the pulse rate too high. Some fellows have the idea of running the rate up until the rudder stops flapping and just vibrates a little, but the writer has found there is so much delay in the recovery of the receiver after a signal stops that the control becomes very one-sided — the "Right" control becomes "all or nothing." It is quite possible to adjust the loading on the receiver when using an RK61 receiver, to take 10 pulses per sec., and still keep a fairly even "Left" and "Right."

Just a word about operation on two R.F. channels. The RK61 receivers have been used here for years with two receivers operating in the 6-meter band; at the Nationals last summer the receivers were turned on while Jim Walkers R.C. Lawn Mower was also working on 2 channels in the same band, and there was no interference at only 50′. That seems to prove that as many as four good clean signals can operate in the same band simultaneously. (The writer uses only crystal-controlled transmitters).

However, may I give a few sad words of advice about multi-channel operation? Using rudder, elevator, and throttle controls, with the first two in great enough quantities to really cut-up, is strictly for the "hot pilots." The mortality rate here is not to be taken lightly, as was well borne out by the writer's fatal first flight at the

1950 NATs. And as "Siggie" Siegfried was heard to say several years ago, as he viewed the mangled remains after a swift power dive, "I should'a give it up." Sometimes those famous last words come back to me, but I'm still not quite sure what he meant he "should'a give up."

On the brighter side, though, two channels can give you two proportional and simultaneous controls, and two pulse-rate controls; some day the writer may tell you about a fifth control that can be had out of this combination for less than an ounce of additional weight in the plane! Now someone probably will figure out how to do all this on only one channel—please let the rest of us in on it, won't you?