COCKPIT RADIO CONTROL

PART TWO

by JAMES R. CUSTIN

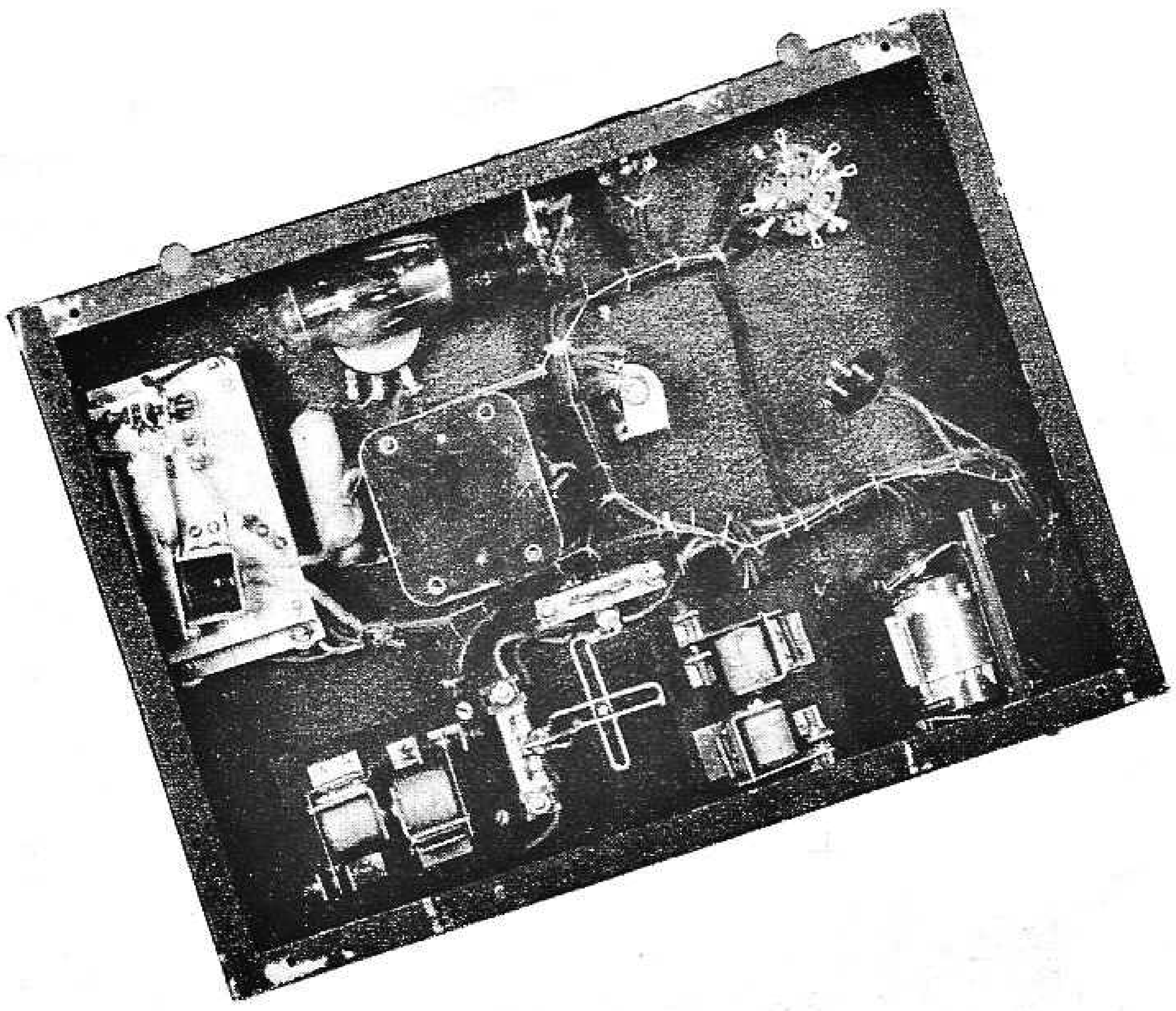

Fig. 11 Under view of modified ground control console

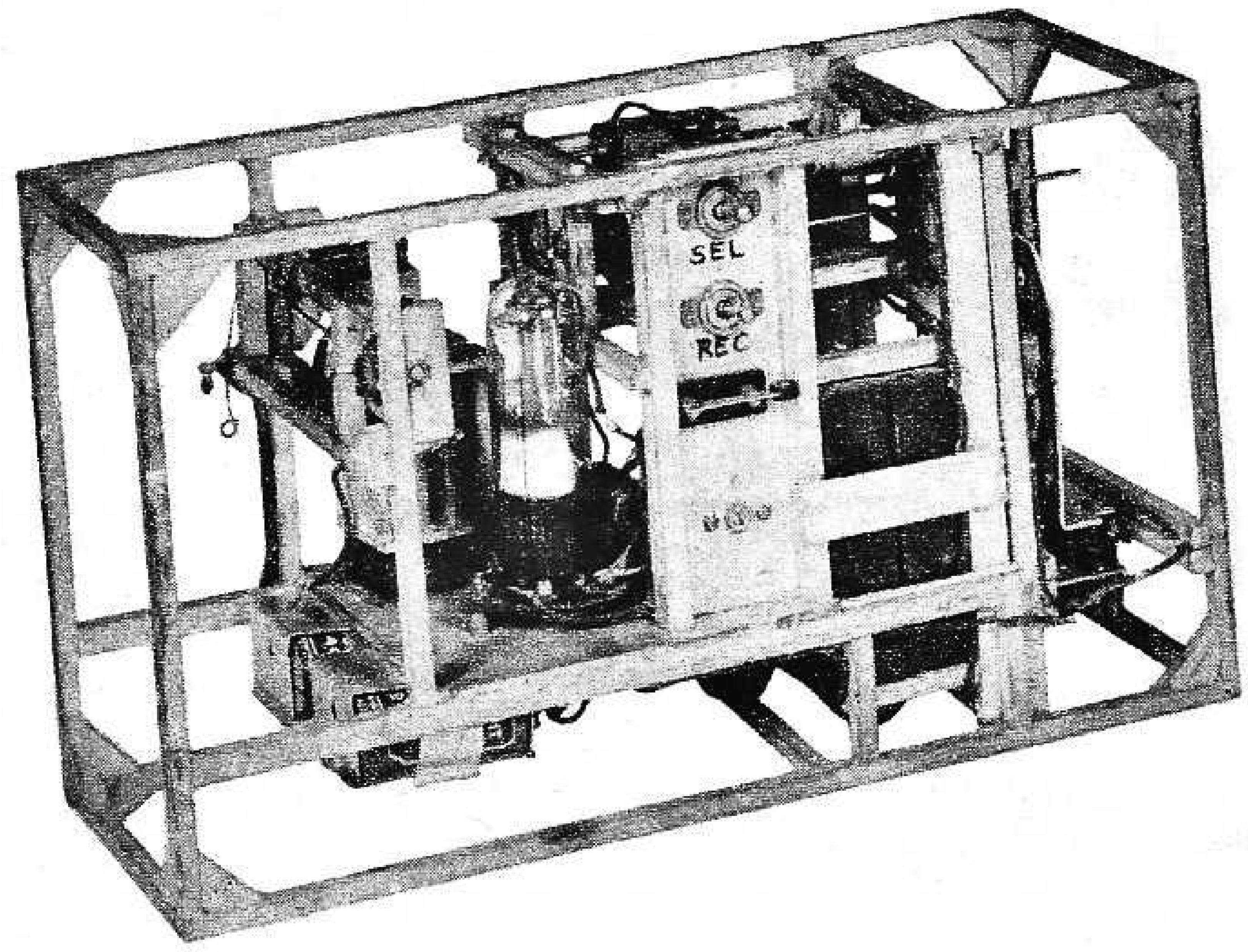

Fig. 9 The entire airborne control system is in a single unit

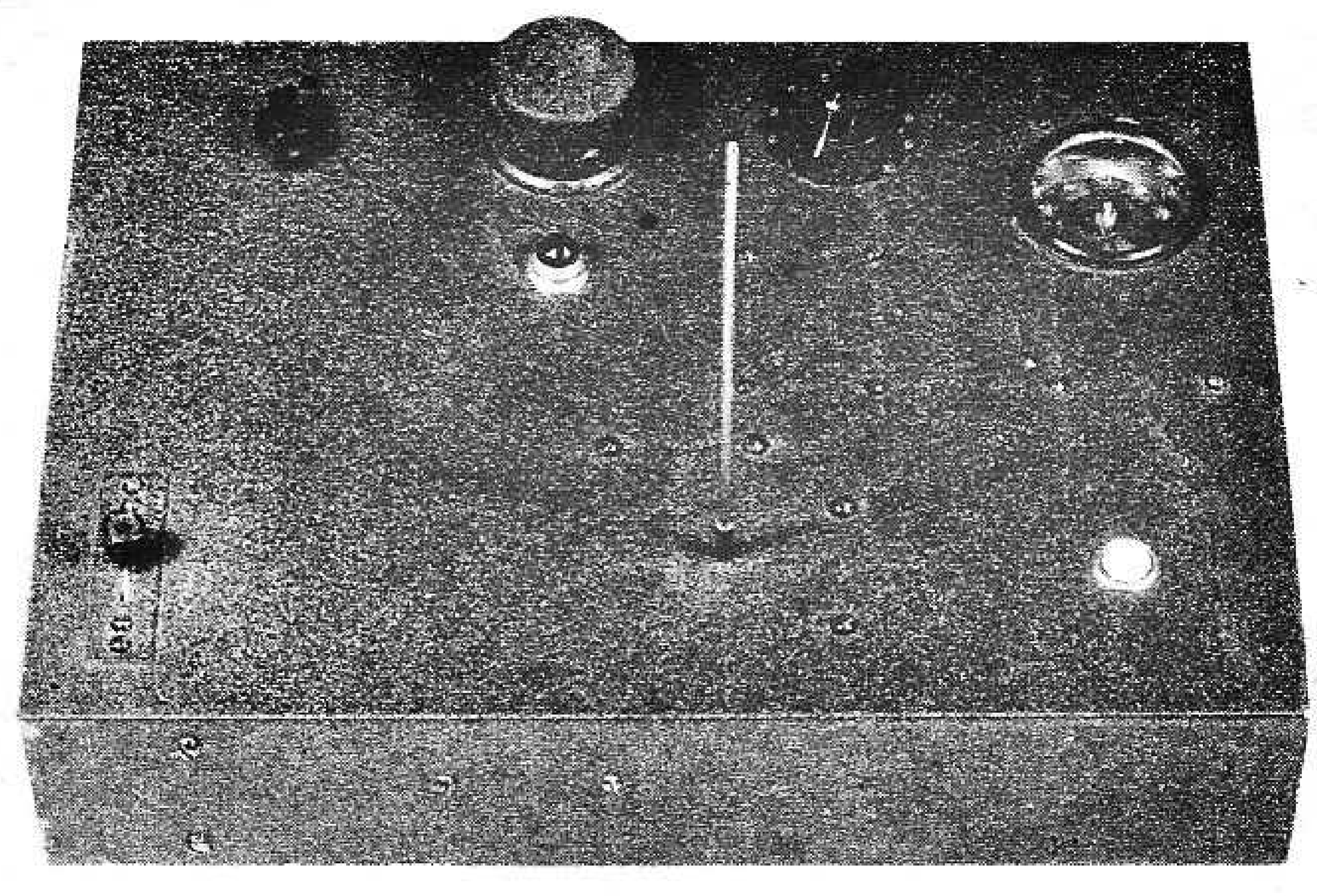

Fig. 10 Top of ground control. The "stick" projects upward

THIS ground control unit proved to be fairly dependable in operation once the "bugs" were eliminated. It was rather interesting to try to fool it by moving two of the controls simultaneously. It wouldn't be fooled. The selector rotor would simply step around until it came to the first contact corresponding to one of the controls selected, run the monitor brush to center on that control, then continue on its way to center the other control—all with complete mechanical non-chalance.

Once the airborne selector had been manually positioned to correspond to the ground selector, it would of course follow it perfectly—in theory.

Unfortunately there were some discrepancies between theory and practice in this respect. One of these discrepancies resulted in a pair of torn pants and a messed-up airplane when the model made a right turn instead of the left requested by the pilot and sailed proudly into a tall tree. Tom, more concerned about the life of the B battery than his dignity, shinnied up the tree trunk with considerable haste. In due time he reached the model and turned off the receiver switch, but he looked a little odd coming home with his trousers patched in critical spots with model airplane tissue!

We later found that the airborne unit had missed a beat because of a sheared wire in the receiver. Engine vibration had proved too much for the single strand hookup wire we used, and it broke in such a way that the loose ends made contact most of the time but occasionally parted. The moral, of course, is to use multi-strand hookup wire.

Lost beats also occasionally resulted from a directional transmitter antenna—a problem that can be overcome with a little more engineering.

After a time we added an "extra pulse" switch in parallel with the contacts of the transmitter keying relay. With this the operator can key the transmitter manually so as to step the airborne selector around to a position corresponding to that of the ground selector. While primarily intended for use in preliminary manual synchronization of the selectors, its emergency value in the event of a lost carrier pulse is obvious.

Interference signals are another possible cause of desynchronization of selectors. The probability of interference can be reduced by allowing the transmitter to remain on the air and keying it off to provide the pulses. This method of operation almost completely eliminates the interference problem and has the added advantage of reducing the receiver B battery drain since, with the carrier on, the receiver B drain is only .2 ma. The disadvantage of this method is that the transmitter takes more average power from its battery.

The selector itself was one of our biggest sources of trouble, however.

Fig. 2 (see Part I in the August 1947 issue) is a top view of the airborne selector that we built for our first model; Fig. 3 is a bottom view of the same device. It will be noted from Fig. 2 that this selector has ten stationary contact segments. This was not entirely a matter of choice. In casting about for suitable ready-made ratchet wheels we came across a pair of gear shaped routers of the type used in drill presses. While these filled the bill perfectly, they had ten teeth; consequently we had to provide ten contact positions, some of which were destined to remain as "empties" although they would all be available, if desired, for gadgets such as a parachute or bomb release mechanism.

The pawl and ratchet mechanism was the source of most of the selector troubles. A helical phosphor-bronze brush spring secured to the top of the router spindle (see Fig. 2) serves as a rotary contactor. The entire ratchet and spring assembly is relatively light, and the brush spring creates a small amount of frictional drag. Nevertheless, the snap action of the armature upon energization of the selector magnet tends to throw the rotor a little more than one step at a time as a result of inertia of the rotor assembly.

The problem was eventually solved by means of the stop arrangement illustrated in Fig. 8 (see page 24). This was not too satisfactory, however, since the small diameter of our "ersatz" ratchet wheels (about 3/8") necessitated extremely close stop adjustments. A rubberband escapement was used to

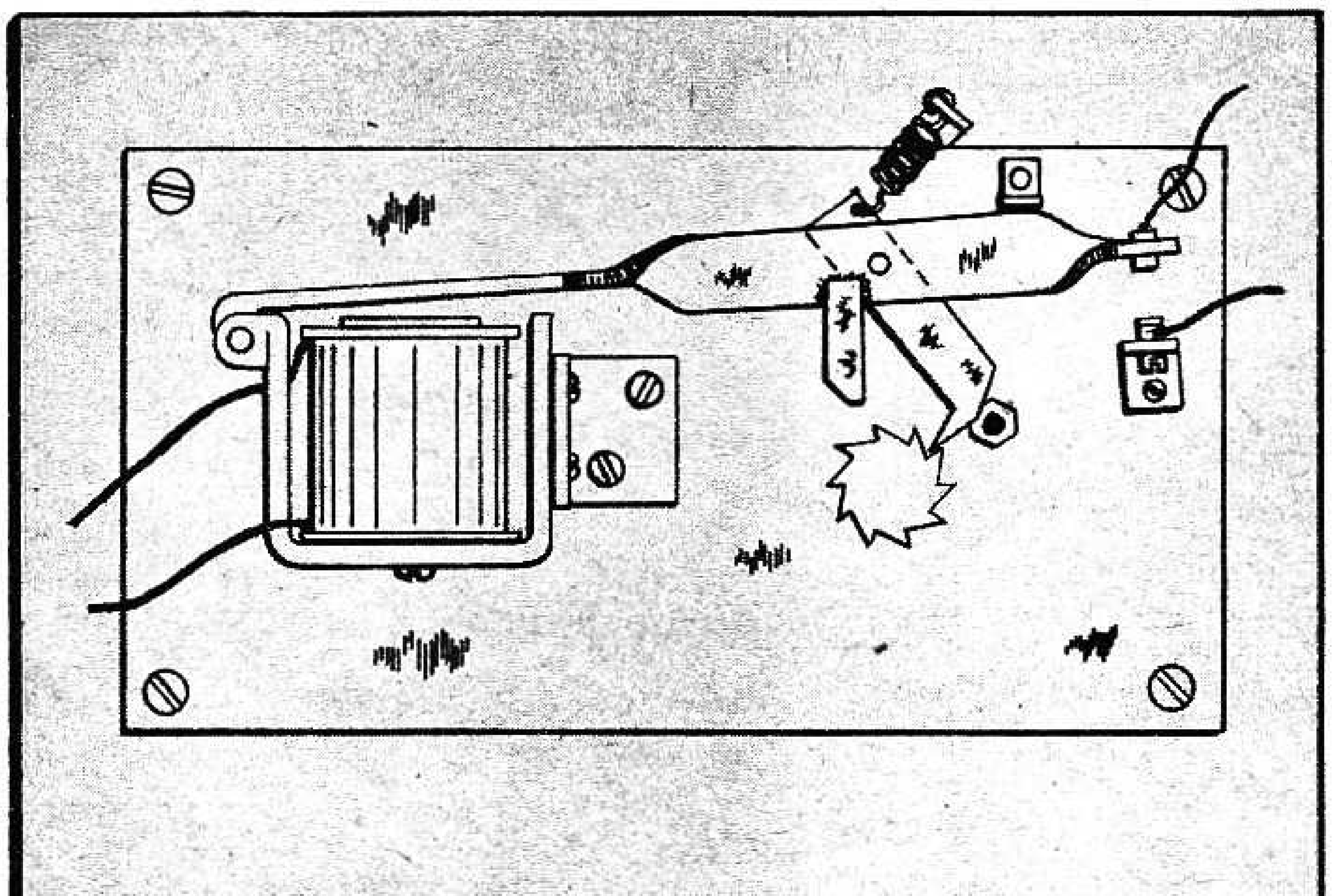

FIG. 8 - PAWL STOP MECHANISM

(Above) Tiny ratchet wheel requires close adjustment

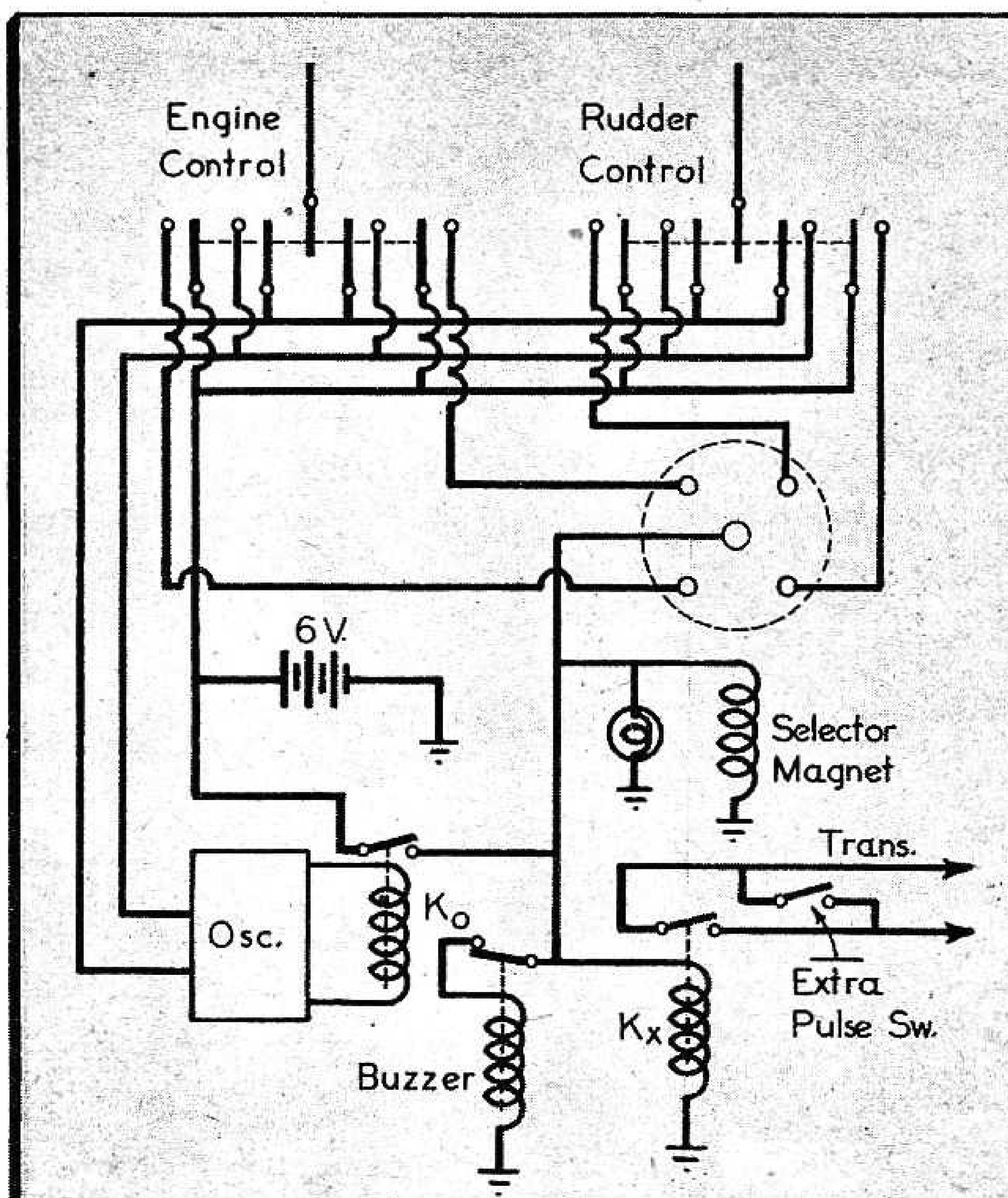

FIG. 12 - MODIFIED CONSOLE CIRCUIT

(Right) Simplified control circuit omits many parts

actuate the airborne selector in a later model. The pawl and ratchet selector originally installed in the console was, for some reason, less temperamental than that in the airborne unit and we continued to use it in a later ground control station.

The selector contact disc shown in Fig. 2 is a homemade bakelite casting having copper contact segments imbedded in it flush with its upper surface. The segments were cut from a disc turned from sheet copper, and were then lightly cemented to a thin sheet metal disc. This assembly was placed, segments upward, at the bottom of the die portion of a mold improvised from cast iron pipe fittings, and the die and plunger were heated in the kitchen oven at 375° F.

After 15 or 20 minutes, when the mold had been brought to the temperature of the oven, it was removed and the required amount of bakelite molding powder immediately poured into the die, onto the segment assembly, and the plunger was inserted on top of it. The die and plunger were then placed between the jaws of a small bench vise which was screwed up as tightly as possible to apply pressure to the bakelite. The mold parts had to be wrapped in towels, of course, so they could be handled without causing blistered hands.

When the casting was removed from the mold we pried the light sheet metal off the contact segments and scraped the cement off the segment surfaces. Connecting wires were soldered directly to the outer edges of the contact segments. Since bakelite tends to warp or swell under the heat of a soldering iron, we covered the contact disc with a wet rag during the soldering operation, leaving only a small area at the edge of the segment exposed for soldering. As soon as the solder connection was made, a squeeze of the rag wetted and cooled the entire disc.

The servos and servo monitors presented no particular problems. We used small permanent magnet Pittman motors and found them quite satisfactory. These are three pole motors, weighing about 1⅝ ounces each and operating on 6 volts. A 10 tooth pinion on the motor shaft meshes with a 48 tooth gear on the lead screw. The lead screw is a piece of brass or drill rod stock having a 6-32 thread along 2½ in. of its length.

Although there is nothing in the system which constrains the lead screw of the monitor unit to turn at the same speed as its airborne counterpart, we found in practice that the two actually stay very well synchronized. Any discrepancies may be compensated for by means of a variable resistor in the monitor motor circuit.

The entire airborne unit, including batteries, is built into a single framework (see Fig. 9) so that it may be removed from the model as a unit for repairs and service work.

Our ground console was constructed on a large receiver chassis (see Fig. 10). A pilot light in parallel with the keying relay gives the operator visual indication of what the console unit is doing. The B battery for the relaxation oscillator is mounted in the console chassis and plug-in sockets enable rapid connection of the console to the transmitter by means of a long hookup cable. The "stick" is a piece of drill rod, about ⅛ in. in diameter, which threads into a small socket at its lower end so it can be removed during transportation of the console.

All relays used in the console were homemade since no suitable 6 volt relays were on the market at the time of our experiments. It is possible, however, that relays which will meet the requirements of the monitor system are now available, and anyone intending to build a radio control unit of this kind would do well to investigate War Surplus listings of aircraft relays.

Although the console diagram, Fig. 6, indicates use of triple pole relays for K_1 and K_2, we actually used only single pole relays, connecting them in parallel to provide the necessary number of poles. When the console was in operation the numerous fluttering relay armatures looked like a field of grain waving in the wind, so we nicknamed the console "the wheatfield."

The console pictured in Fig. 10 is actually a later model than that diagramed in Fig. 6. Fig. 11 is a bottom view of this later console.

In an effort to avoid some of the problems which had bedeviled us in our first experimental unit, we compromised with our desires and developed a modified system somewhat along the lines of that which the Army uses in its small target models, employing our automatic selectors, however, rather than the multichannel system used by the Army.

Fig. 12 is a diagram of the ground console for this system. It will be seen that there are no monitors in this console, and it is scarcely a "wheatfield" since the number of relays has been cut to two.

In using this modified control unit, the operator moves his controls in the same directions as with the original "wheatfield," but in doing so he merely closes one of the two double-pole switches linked with each control. One pole of this switch closes the relaxation oscillator circuit and thus starts the selector stepping, just as in the "wheatfield." When the selector arrives at the segment corresponding to the selected control position, it closes a holding circuit through the other pole of the switch, and the selector remains on this segment until the switch is released.

Monitoring is effected by means of a high frequency buzzer in parallel with the transmitter keying relay. Thus the operator hears a series of short "beeps" from the buzzer, designating each of the selection pulses, followed by a long "beep" for the control pulse. The long "beep" continues as long as he holds the switch closed. He must therefore estimate control position by the length of the long "beep" and by observing the response of the model.

A pilot light wired in parallel with the transmitter keying relay provides a visual check on the buzzer.

The airborne unit used with this console is exactly the same as that used with the "wheatfield," and it works in the same way.

Since, like the "wheatfield," the modified console requires sequence selectors, its biggst advantage over the "wheatfield" is its simplicity. A secondary advantage lies in the fewer relays it requires. Experimenters interested in developing a cockpit type control system may do well to reverse the procedure we followed and begin their experiments with a circuit like

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that shown in Fig. 12. When this has been perfected, the necessary parts can be added to develop a full-blown "wheatfield."

This article would not be complete without a few words of grateful acknowledgment to the people who helped us in our radio control experiments, and particularly to: Bob Stoneman, who worked with us constantly; Ed Schunke, who entrusted us with a twin cylinder engine of his own design and construction to give our ship the extra power it needed; our "hams," Bob Schmidt and Keith Hayes; the local model supply dealers who aided us in getting unusual parts in a hurry; and our long-suffering mother, who usually found her kitchen turned into a radio lab just as she wanted to do an important piece of cooking.

And to our readers who are doing experimental work with our favorite toy—we hope you've got everything under control!