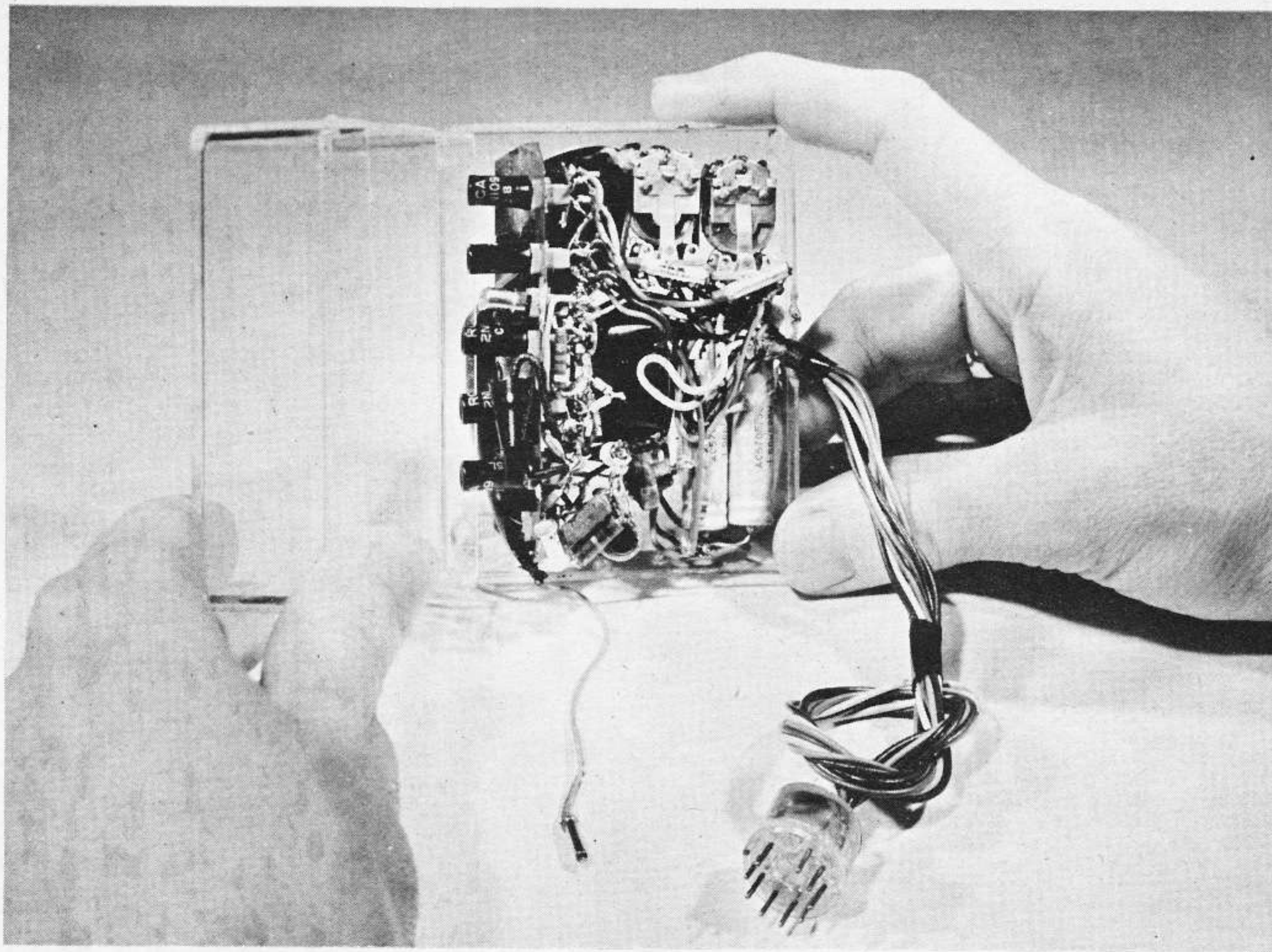
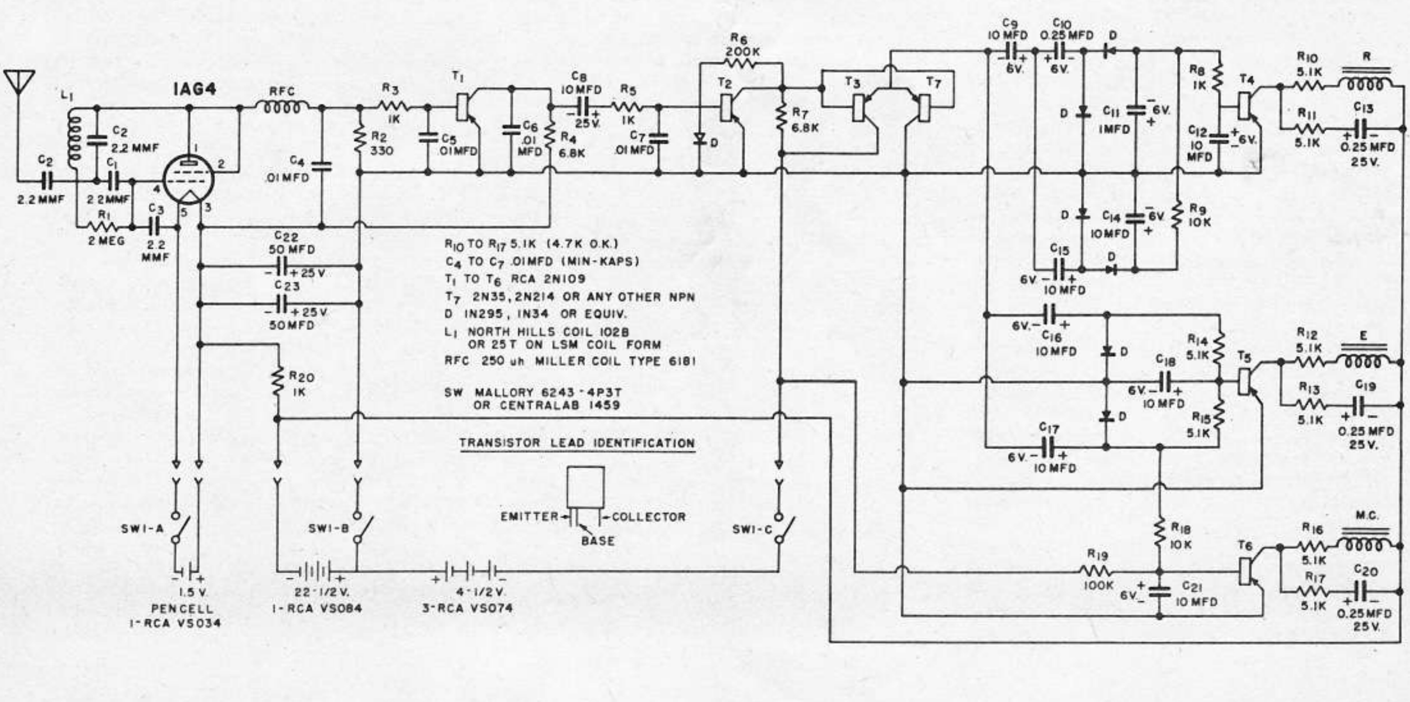


Even if this radio control offering sounds "over your head" don't miss reading it! Author Gerald Herzog gives you an insight into the symmetry detector . . . small wet cells . . . even WW-II missiles . . . as he describes —

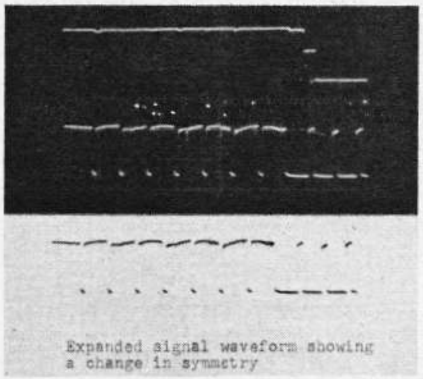
SHRINKING THE "WAG" RECEIVER



■ To my way of thinking, Dr. Walt Good's dual proportional control system (see WAG-TTPW, January and March 1957 *American Modeler*) comes as close to giving true scale control of a model plane as any system yet devised. As a radio ham but a model plane tyro, this system appealed to me at once when demonstrated by Ivor Winby. Unfortunately, my Trixter Beam then under construction seemed a little small to carry the equipment for this system if the wing loading was to be kept within reason.

My solution to the problem was to replace most of the tubes with transistors which cut the battery weight by a substantial factor. My transistor version now flies in my Beam with a total plane weight of 2¾ pounds. Battery life is up to 10 hours on the 22½ volts B battery, 6 to 10 hours on the single pen cell used for the A battery, and practically shelf life on the size AAA cells used for the 4½ volt transistor supply.

Although the circuit may appear more complicated than the tube version, it is actually quite simple. Desiring high reliability and freedom of critical adjustments, the circuit was conservatively designed with a wide gain margin, hence


Expanded signal waveform showing a change in symmetry

the greater number of transistors. The super-regen section was left a tube stage because of insufficient time to work out a really reliable transistor super-regen circuit at 27 mc.

Circuit used is non-critical; any 1AG4 works in it since there is a surplus of gain following it. The 2mmf from grid to filament decreases the feedback and increases the tube conduction to approximately 0.5 ma. This reduces the tendency to overload near the transmitter and allows a hand launch with the control box in one hand and the plane in the other.

A super-regen detector is interesting in that when operating at low plate voltages and low plate currents, a very strong signal can cause an increase in plate current instead of a decrease, thus reverse the action of the elevator which depends on the phase of the incoming signal (Down Elevator Club members take note!) The 2mmf capacity from grid to filament together with the 2mmf across the tank coil make the circuit less critical of the tube used. Frequency does not shift appreciably when changing tubes and they all oscillate about the same. The LSM coil form (red dot core) was wound with 25 turns of #33 wire for operation at 27 mc. A North Hill Coil 102B, 3 to 5.5 mh works good just as it comes.

First transistor T_1, direct-coupled to the tube circuit, provides enough gain to drive the second transistor T_2 from cut-off to saturation, giving a clean clipped 4½ volt peak-to-peak square wave. Because of the high gain, 0.01 bypass capacitors are necessary to get rid of the quench frequency. Several capacitors of the same size are used at different points rather than just one large one to give a sharper frequency cut-off. This effectively gets rid of the quench frequency without appreciable frequency distortion of the desired signal.

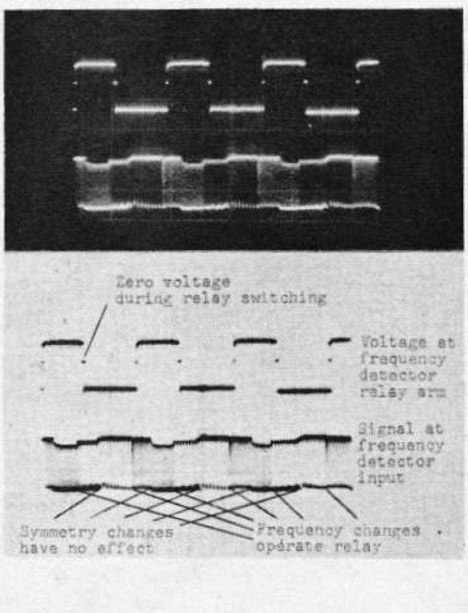
Filtered signal is fed to the frequency and symmetry detector stages by a unique combination of a PNP and a NPN transistor complementary symmetry emitter follower pair (like a cathode follower).

The NPN can be replaced by a 500 ohm resistor from the emitter of T_3 to ground if desired, but this increases the drain on the 4½ volt battery from 1½ ma to about 6 ma. Output impedance of the PNP-NPN pair is 50 ohms and does a very good job of driving the relatively low impedance frequency and symmetry detectors. Because these detectors are low impedance, inexpensive diodes such as the 1N295 (41c) can be used without fear of temperature problems. Other diodes such as the 1N34, 1N54, etc. may also be used.

Flights in freezing temperatures have been made without trouble; tests in an oven at 140°F, as well as summer flying have shown high temperatures to be no problem. The symmetry detector, or pulse width detector as Dr. Good has called it, is based on the same principle as his, but is lower impedance. It operates reliably on a 60-40, 40-60 waveform.

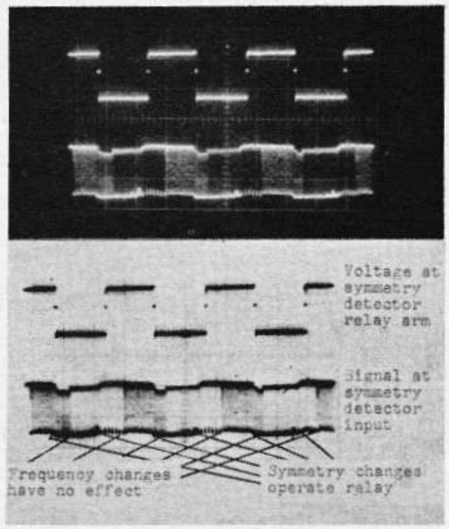
As in the tube version, voltage from the symmetry detector is used to keep the motor control relay de-energized as long as a tone is present. Loss of the tone allows bias from the 4½ volt supply to cause T_6 to conduct and closes the relay. Although the motor control circuit was not used in my Beam, it has been thoroughly bench tested and performs very well.

Frequency detector is a pulse counter circuit balanced against a reference counter circuit. This arrangement provides a small positive output for frequencies below 250 cycles, and a negative output sufficient to drive the output transistor to full conduction for frequencies above 300 cycles. A much simpler frequency detector arrangement using only one diode is possible but its temperature stability and tolerance to battery variations are questionable. The more complicated circuit seemed worthwhile.



Output transistors are limited in their conduction by the coil impedance of the relays and the extra circuit resistance which was added to reduce battery drain. The 2 ma. conduction has given very reliable action. The 5.1 K in series with the relay may be reduced or eliminated if higher current is desired. Current falls to zero for the opposite command signal. Gem relays were used as they came and no adjustments were necessary.

This set requires only a quick distance check for safety's sake and away she goes. No plate meter or other equipment is needed for tuning. Just tune for the center of response to the pulsing signal as observed by the flutter of the rudder.



Actuator supply consists of a battery of 4 pen cells to give plus and minus 3 volts. To reduce the drain on these cells and prolong their life, a regulator system is used with each Mighty Midget motor. This consists of two #222 flashlight bulbs in series with each motor. The fact that the filament resistance of a light bulb goes up very sharply as it is heated by current flowing through it has been used to control the current to the motors. When the cells are fresh, large currents tend to flow, but this heats the filaments of the bulbs, increasing their resistance and limiting the current. For weak cells, the bulbs do not heat up as much, resulting in a lower resistance in series with the motor. The regulatory effect maintains the stalled motor current between 160 ma and 120 ma for battery variations from 3 volts to 1½ volts or only 1.3 to 1, whereas without this system the current would vary 2 to 1 and would be more than twice as high (420) for fresh cells, running the batteries down much faster.

Since the same cells supply both motors, they last for only about 30 minutes of flying time, but then are recharged and used several times. Silver cells for a 1½ volt battery complement without the regulator bulbs would weigh about the same as the four pen cells and except for the cost, are desirable. A 3 volt battery of Silvercels would be fine for a little larger ship or heavier wing loading.

Miniature 2 volt lead acid cells now sold for cigarette lighters have been tested and when new, are excellent for use on the motors. Unfortunately, life tests under charge and discharge cycling have been disappointing. Some units stand up fine under repeated charge and discharge, but too many failed after one or two charging cycles to trust them

(*Continued on page 51*)

Shrinking

(*Continued from page* 25)

where reliability really counts. The failures were all traced to the internal connection of the terminal leads to the leads from the plates. Discharge action under heavy load conditions tends to eat away this connection and recharge deposits the lead at some other spot, very quickly resulting in an open circuit to one of the plates even though the cell may be fully charged. Since this connection is at the bottom of the cell, improved life might be obtained by operating the cells inverted so that the acid is not in contact with the terminal lead connection during discharge. A controlled life test on several cells operated in this fashion is now being made and the results of this and other life tests on these cells will be reported.

Many enjoyable and successful flights have been flown with this transistorized version of the Good receiver; I feel deeply indebted to him for developing this fine system.

It is interesting to know that during World War II the Germans used a system somewhat similar to this guide a ground to air missile. They called it the "Burgund Guidance System"; it employed two sets of tones which caused the rudder and elevator to flutter back and forth between extreme positions, the dwell times determining the control action. The control stick or Knuppel as they called it, operated brushes on two drums to vary the dwell times, much as is now used for some forms of proportional rudder control. I want to thank Mr. Ivor Winby for first bringing Dr. Good's system to my attention and demonstrating its operation.

Note: The L1 coil is obtainable from North Hills Electric Co., 402 Sagamore Ave., Mineola, N. Y. The Pie-type RFC is Miller #6181. Relays are Gem, 5,000 ohms.