Two-Tone, Pulse Width Transmitter For Dual Proportional Radio Control

Dr. Walter A. Good presents the conclusion of his contest tried-and-proven "WAG D-P" system

■ In many ways the Dual Proportional Transmitter is not much different from the ordinary tone transmitter with a few added devices. The transmitter must be able to produce the four basic audio wave forms illustrated in the earlier article. In addition, these four wave forms must be pulsed, one at a time, in the proper ratios to produce the proportional response of the rudder and elevator. The sending of carrier operates the engine and the fail-safe provision.

The transmitter is composed of four principal sections: 1) Rudder Pulser; 2) Elevator Pulser; 3) Tone Oscillator; and 4) R. F. Transmitter. The function of each section will be described.

Rudder and elevator pulsers are the same as the pentode multivibrator type described in McEntee's Column (Jan. 1955) except they are now operated on 45V instead of 90V. This still gives 3 ma through the 8000 ohm Sigma 4 F relays. The Sigmas are especially recommended because clean contact switching is essential to proper proportional operation. McEntees 1AG4 version (Oct. 1955) is quite acceptable but remember that *two* pulsers are needed and his control box would require a one megohm pot on each of the two output shafts and an extra pulser. A fully proportional control box allows stick movement to all corners of the box. McEntee's or the one described in Nov. 1956 by DC/RC member Bill Holman will do the trick.

Incidentally, the electronic pulser is a balanced device and hence the critical parts (0.25 mfd, 15K and 100K) should be well matched. If you use different tubes or components than shown in this diagram, then follow John Worth's adjustment procedures which he discusses in the December 1956 *American Modeler*. The two pulsers are shown in Figure 6 on the left-hand side.

The tone oscillator is another multivibrator circuit but this time the output tone is either 100 or 500 cps. The four wave forms are obtained by switching in the grid circuits. Switches are the contacts of the pulser relays. The tone oscillator is shown on the right side of Figure 6. Note the rudder relay switches the grid return from a low voltage to a high voltage. This provides the two tones. The elevator relay switches from one side of the grid resistor string to the other. This makes the tone wave lopsided, either 80/20 ratio or 20/80. Since the pulser relays are independent, the outgoing tone wave depends on which relay contacts happen to be closed at that instant. There are four combinations of the relay contact positions which yield the four-wave forms. The output of the plate point M (in Figure 6) of one of the 3V4's is connected to the transmitter and provides the modulation. The carrier signal is sent by pressing the "panic" button which removes the 180V B plus from the tone oscillator and causes the instant cessation of the oscillation.

Circuits for both a 27¼ mc and a 52 mc transmitter are shown in Figure 7. The circuits are both conventional oscillator-doublers but are slightly different from each other. The 27¼ mc unit uses a 13.6275 mc crystal in a standard oscillator circuit. Oscillator output is fed to the grid of the 3B4 doubler amplifier where the frequency is doubled to 27¼ mc and emitted on the whip antenna. Grid of the 3B4 is also impressed with the audio modulation from the tone oscillator. This type of transmitter emits about one-half watt and is almost completely free from oscillator leak-through. Hence, practically no close distance "swamping" of the receiver should be encountered.

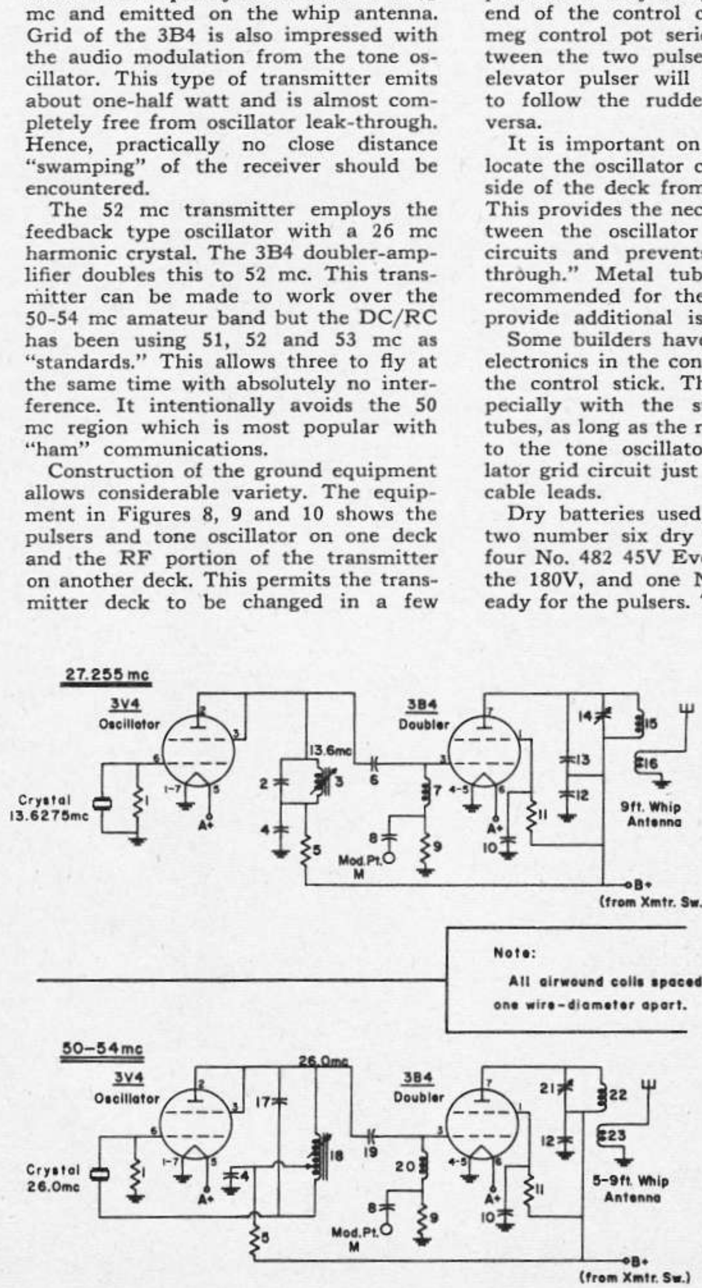
The 52 mc transmitter employs the feedback type oscillator with a 26 mc harmonic crystal. The 3B4 doubler-amplifier doubles this to 52 mc. This transmitter can be made to work over the 50-54 mc amateur band but the DC/RC has been using 51, 52 and 53 mc as "standards." This allows three to fly at the same time with absolutely no interference. It intentionally avoids the 50 mc region which is most popular with "ham" communications.

Construction of the ground equipment allows considerable variety. The equipment in Figures 8, 9 and 10 shows the pulsers and tone oscillator on one deck and the RF portion of the transmitter on another deck. This permits the transmitter deck to be changed in a few minutes to a different band. Note that the pulser relays are insulated from the metal chassis. This is necessary because the armatures are connected to the relay frame and must be left floating in this circuit. Arrangement of parts on the pulser deck is not critical and may be redistributed to fit the builder's particular space. It is important, however, that the 100K grid resistors in the pulsers be kept as close to the grid terminals as possible. If they are placed at the other end of the control cable near the one meg control pot serious interaction between the two pulsers will occur. The elevator pulser will "lock in" and try to follow the rudder pulser and vice versa.

It is important on the transmitter to locate the oscillator coil on the opposite side of the deck from the amplifier coil. This provides the necessary isolation between the oscillator and the antenna circuits and prevents undesired "leak-through." Metal tube shields are also recommended for the two RF tubes to provide additional isolation.

Some builders have placed the pulser electronics in the control box along with the control stick. This works well, especially with the subminiature 1AG4 tubes, as long as the relays are kept close to the tone oscillator. The tone oscillator grid circuit just won't tolerate long cable leads.

Dry batteries used by the writer are two number six dry cells for filaments, four No. 482 45V Eveready in series for the 180V, and one No. 482 45V Eveready for the pulsers. The use of a separ-



Component Values

1– 47k, 1/2w.
2– 33 mmf, mica
3– 18 turns, No. 22 enameled wire close wound on CTC 3/8 in. red slug coil form
4– 0.01 mf, ceramic
5– 15k, 1w.
6– 33 mmf, mica
7– 100 microh. National R-33, RFC
8– 0.01 mf, ceramic
9– 2.2 meg., 1/2w.
10– 0.01 mf, ceramic
11– 33k, 1/2w.
12– 0.01 mf, ceramic
13– 10 mmf, mica
14– 3-25 mmf, variable
15– 12 turns, No. 16 wire, airwound, 1/2 in ID
16– 4 turns, No. 16 wire, airwound, 3/4 in. ID, couple close to end of 15
17– 5 mmf, mica
18– 16 turns, No. 22 enameled wire close wound on CTC 3/8 in. red slug coil form, tap at 4 turns from cold end.
19– 10 mmf, mica
20– 20 microh. Miller RFC
21– 3-12 mmf, variable
22– 8 turns, No. 16 wire, airwound, 1/2 in. ID
23– 2 turns, No. 16 wire, airwound, 3/4 in. ID, couple close to end of 22

ate pulser B plus battery helps isolate the pulsers from the tone oscillator and transmitters. Other supply arrangements are feasibly as long as they are well filtered. These multivibrators are notorious for "locking-in" with voltage spikes or electrical noise from any source. So use plenty of large condensers with dynamotor or vibrator supplies.

Also note the 3B4 is rated at 1.25V on the filament. If you use another filament supply, such as a 2V wet cell, be sure to place a dropping resistor in the 3B4 filament circuit.

The battery drain of about 20 ma (Xmttr 15 ma, tone OSC 5 ma) was measured when the writer's batteries were 165V instead of 180V. Actually the transmitter works well from 180V down to 135V so a set of batteries should last a season of active flying. The transmitter filaments draw 430 ma and the pulsers and tone oscillator draw 500 ma.

After the transmitter is completed the tune-up procedure consists of checking the pulsers, setting the tones, and tuning the transmitter.

The pulsers usually work with no coaxing. I set the pulser relay to operate in the 1.5 to 1.8 ma region and leave it there. An accurate test of each pulser can be made by connecting a zero center meter and two batteries to the relay contacts. This stimulates an actuator and presents a quantative measure of the pulse ratio as a function of control stick motion. This tester is described in the

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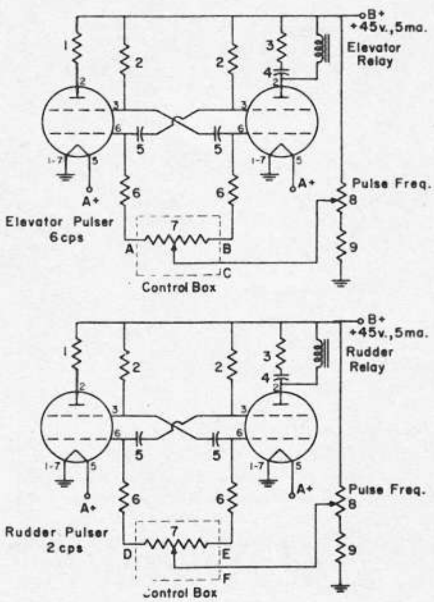
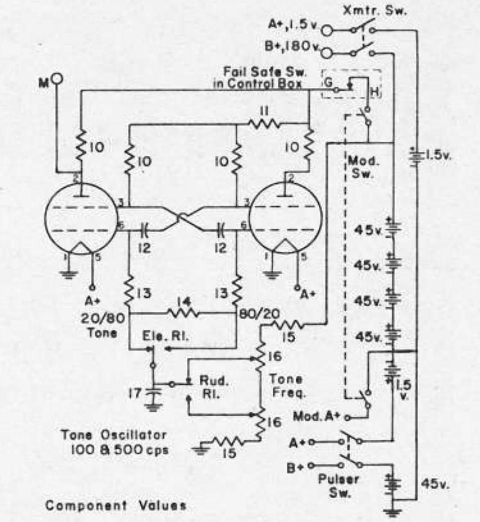
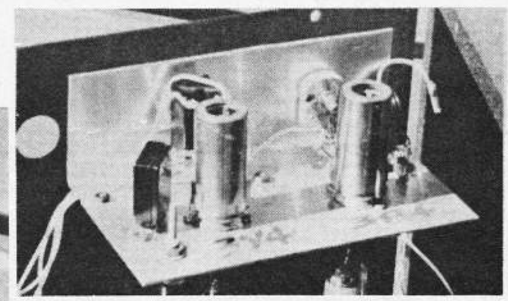


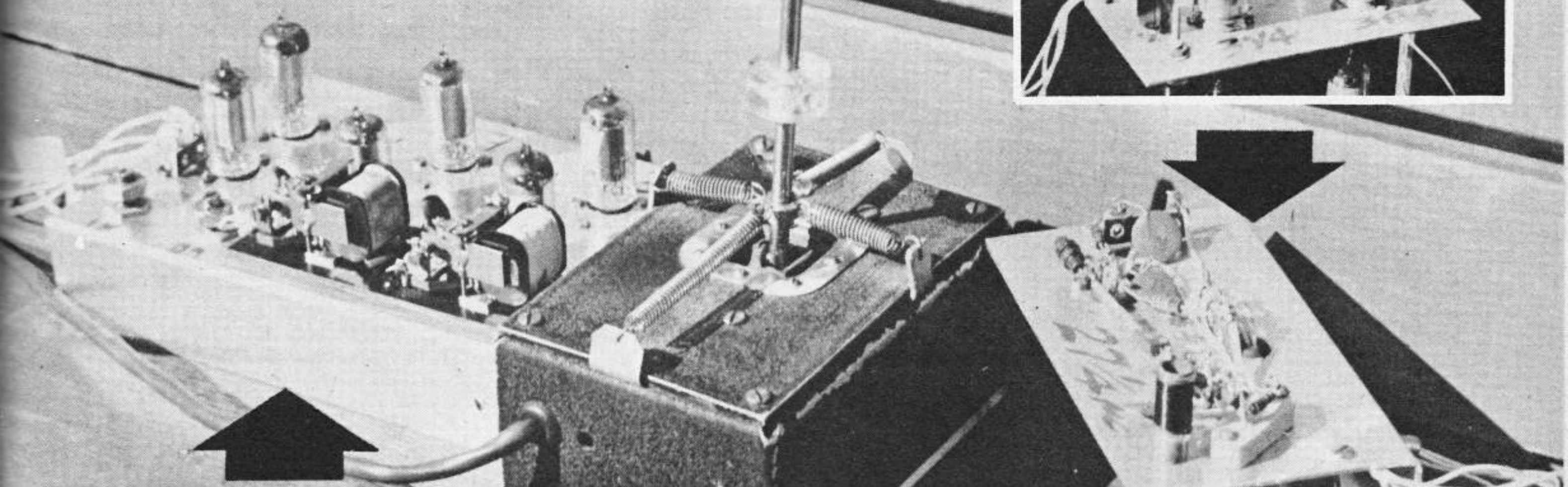


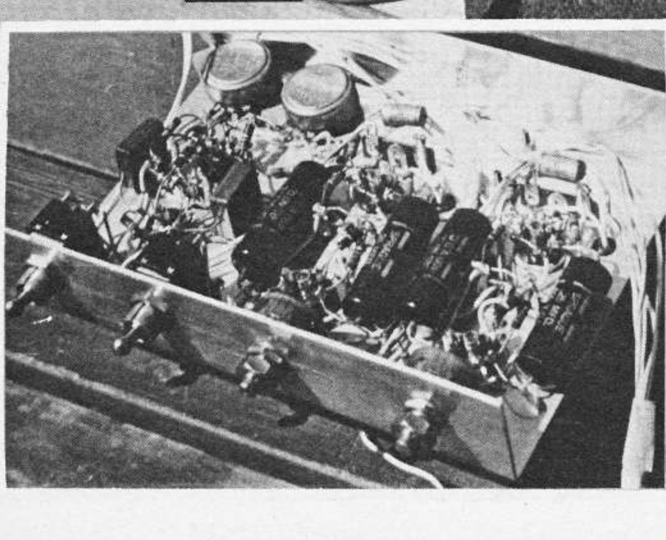
Component Values

1 — 8.2k, 10%
2 — 15k, 5%
3 — 10k, 20%
4 — 0.1mf., 200v.
5 — 0.25mf. paper, matched pairs
6 — 100k, 5%
7 — 1meg., Ohmite type AB pot.
8 — 50k pot.
9 — 4.7k, 20%
10 — 47k, 5%
11 — 82k, 5%
12 — 0.005mf., 5% or closely matched, mica
13 — 470k, 5%
14 — 1meg., 5%
15 — 4.7k, 10%
16 — 100k, pot.
17 — 0.001mf. ceramic
Tubes — 3V4
Relays, 8k Sigma 4F

Left to right below: Pulser-modulator, dual proportional box, transmitter deck (inverted). At right is xmtr deck in upright position.







Underside of pulser-modulator deck for dual proportional rig (left). In photo at top of opposite page we see Dr. Good operating transmitter at National Radio Control event in Dallas last summer. Details of meet appear in 1957 Edition of "Air Trails Model Annual."

Good Transmitter

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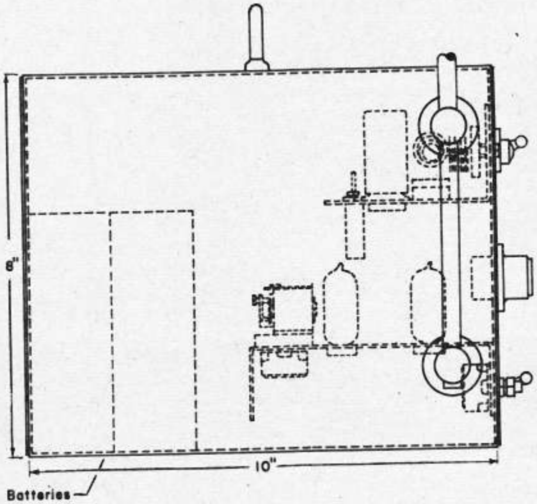
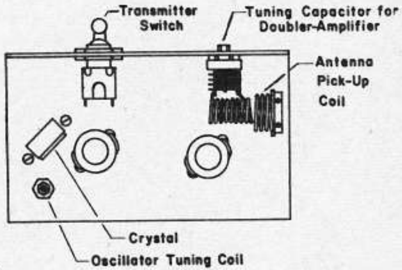
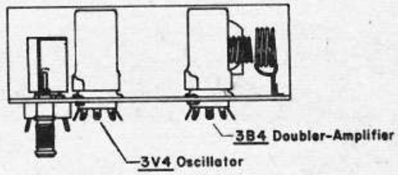
June '56 R/C column. I like to have the center stick yield a 50/50 pulse ratio and the extreme positions give at least 90/10. Occasionally, the unbalance in the 3V4 tubes will not allow symmetrical pulse widths. Interchanging the tubes will usually cure this.

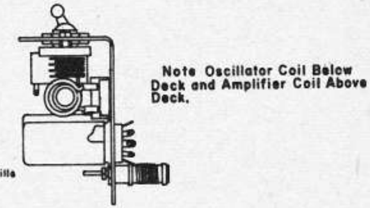
The tone oscillator is set to the two tones by adjusting the 100K pots. Rudder relay may be held against the high or low tone contact with your finger. Low tone should be between 80 and 120 cps and the high tone between 500 and 600 cps. Tones can be referenced to an audio oscillator or to appropriate piano notes. Switching the elevator relay armature from one contact to the other should not change the frequency by more than a few cycles. The tone ratio is preset by the choice of the 470K—1 Meg—470K resistor string and should give about 80/20 and 20/80. A cathode ray oscilloscope is a very handy tool at this time to observe the voltage pattern at point M. The patterns should appear very similar to those in Figure 1 of the earlier article. With the pulsers in operation the switching from one wave form to another should appear almost instantaneous with no evidence of contact bounce or dirty contacts.

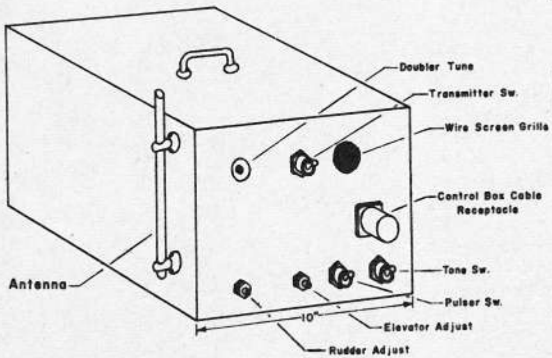
RF portion of the transmitter is aligned in the usual way. Remove the 3B4 and apply power only to the 3V4 crystal stage. Tune the slug of 3 (Fig. 7) until the plate current dips and then

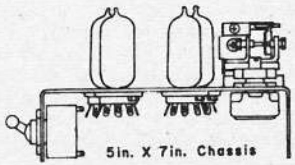


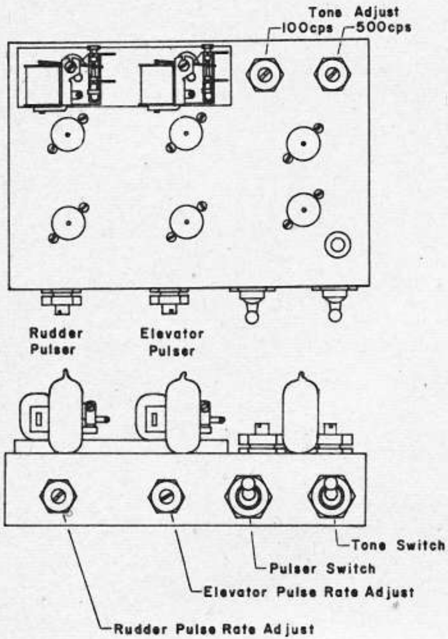












set the slug so the plate current is on the stable, or shallow, part of the curve. Plug in the 3B4 and slip a brown bead lamp to the antenna output coil 16. Tune the 3B4 condenser until the lamp is the brightest, then go back and retune 3 to obtain even more brilliance. However, 3 should be set safely enough that the oscillator will pass the "finger test." Touch the plate end of 3 with a finger and knock the stage out of oscillation. Removal of the finger should allow immediate reoscillation. If not, readjust 3 until it does, even at some sacrifice in output. Final RF transmitter test is to connect 16 to the antenna and adjust the spacing between 15 and 16 (and retune the condenser) until a field strength meter shows maximum radiation.

Now that you have a complete transmitter and receiver the time has come for the final check of the combination. Purpose of this check is to measure the receiver response to the four wave patterns of the transmitter. Set the transmitter several feet away, remove the antenna and replace with the brown bead lamp. Turn on the transmitter and tone oscillator but not the pulsers. Now read the voltages at points A, B and C in the receiver with the pulser relays held in the different positions. The voltage should be greater than minus 7V to cut off the relay tube. We use a Heathkit VTVM Model V-7 with a 100 megohm probe in the DC lead. Next best is to read the receiver relay currents and see if they are maximum or near zero depending on the particular condition. If the receiver doesn't respond properly find a friend with a scope to localize and correct the trouble.

Once the transmitter and receiver are satisfactory as checked above, clip the zero center meter tester to the rudder and elevator relays and observe for proper operation all the way from the control stick to the movement of the simulated actuator.

A word about the polarity of the actuator and relay connection. We have somewhat arbitrarily standardized on the following. When all receiver relay coils are deenergized the rudder and elevator are in "left" and "up." A broken A or B battery connection would give this result. Of course, the most likely "fail safe" condition is either carrier or no signal. This energizes all receiver relays and opens the rudder and elevator actuators. The case of no current in the fail safe relay and full current in the rudder and elevator delays results in left and down—this is to be avoided!

The "final final" check is a distance test at the field. At one-half mile the plane should work when held above the head. At one-quarter mile, it will usually work on the ground. Tune the receiver coil back and forth until the limits of rudder operation are found, then set the tuning screw in the center of these limits.

On your first few flights, it is highly recommended that an experienced elevator man be on the stick. He can quickly correct for any mistrim in the plane and steer the plane to a safe altitude so you can take over. The proportional elevator is permitting you to do many more maneuvers than before, but at the same time it can also get you into trouble. Just note the large membership, including yours truly, of the Down Elevator Club! It will take about twenty flights to gain confidence in yourself and the elevator, so don't get discouraged.

I find that this system is easiest to fly if spring centering is used on the actuators as well as the control stick. In fact we usually double the centering rubber bands on the actuators of a new ship until we get the "feel" of control response.