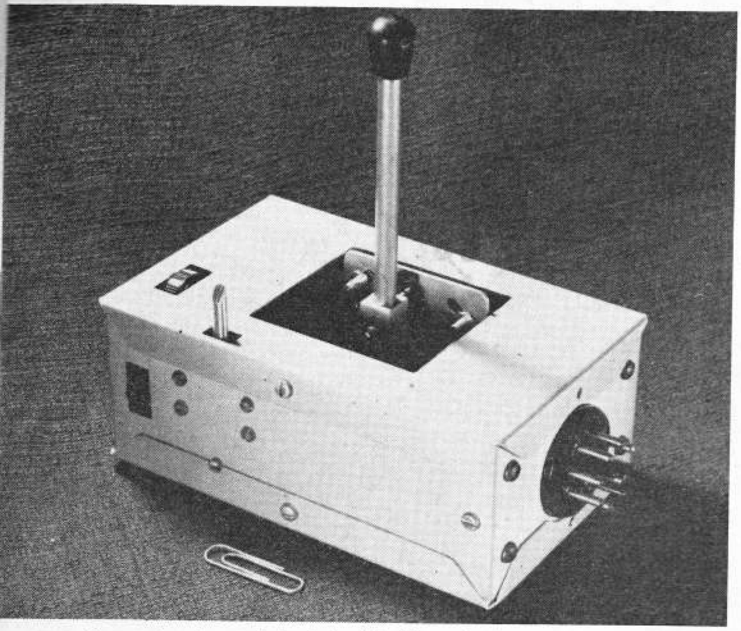
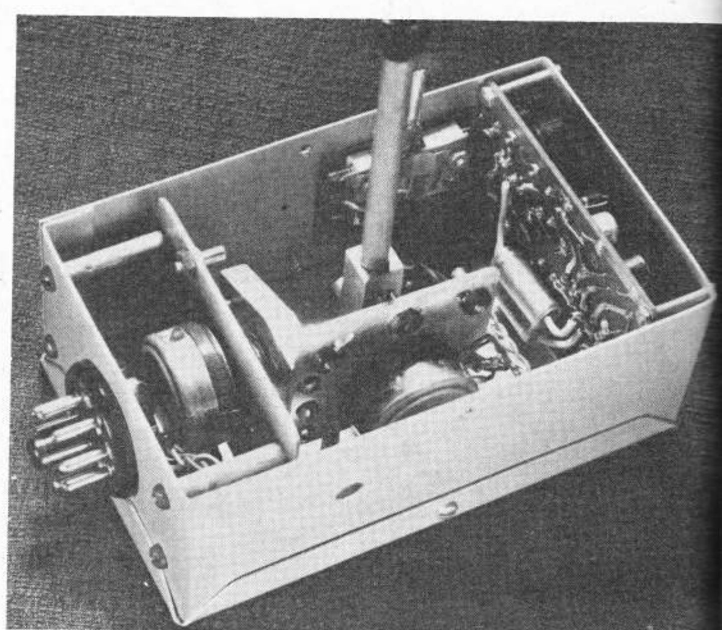
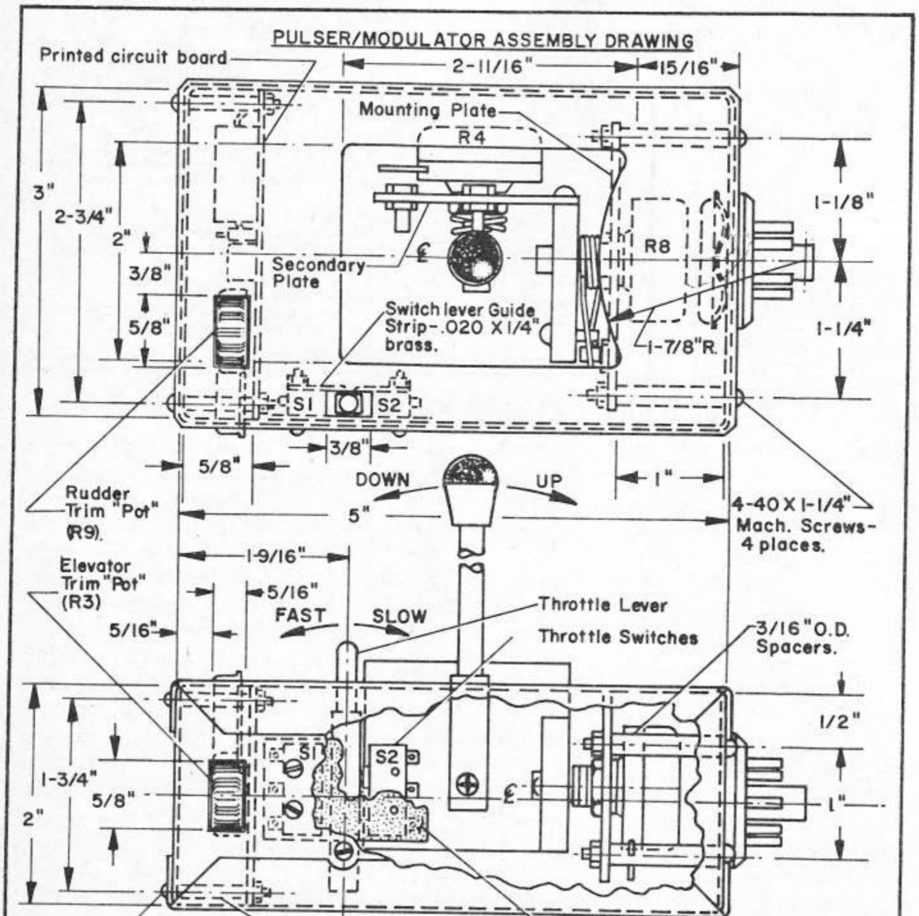
PART TWO PULSER/MODULATOR ...B & D



Compact and rugged the Pulser/Modulator has been designed and laid out for minimum space and ease of handling, plus accessibility of controls.



A look inside of the control box indicates the engineering and planning by the designers to contain all parts in the smallest container.



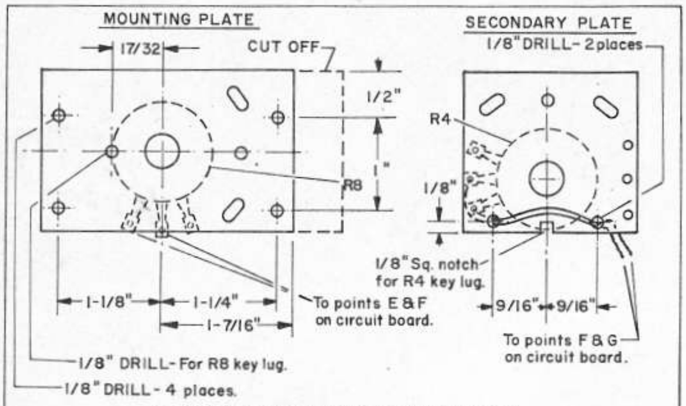
► This pulser-modulator is intended for use with the "B&D Pulsatone" dual proportional receiver described in Part I of this series. (See MAN, March '63). By changing the values of a few components the pulse rate can be lowered and the maximum pulse width ratio increased to permit use with other pulse-width pulse-rate proportional systems such as "Galloping Ghost" and "Kickin-Duck."

The P/M was designed for use with ground based MOPA transmitters such as "WAG," "TTPW," and "Lorenz." However, it is entirely possible to build the stick assembly, circuit board, and throttle switches into MOPA hand-held transmitters that have adequate space in the case. The power output of hand-held transmitters is generally lower, and the ease of handling the light weight stick box as compared to holding a complete transmitter largely compensates for the lack of mobility of the ground based jobs. And, too, there must be literally hundreds of used ground based transmitters available at very low cost. (O.K., we admit it! We are working on a hand-held for next season!!)

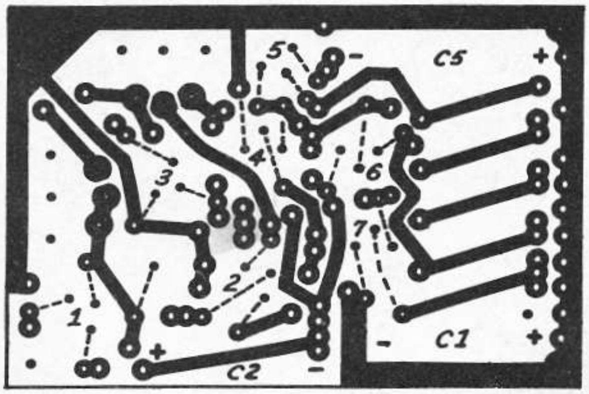
The circuit consists of a pulser (Q1 thru Q4), a tone generator (Q5 and Q6), a clipper amplifier (Q7), and a voltage amplifier (VI). The pulser circuit was derived from a circuit designed by Mr. John Phelps, manager of semiconductor products application engineering at General Electric and an active East Coast RC flier and experimenter. Mr. Phelps's pulser is, in our opinion, the finest ever offered the RC fraternity,

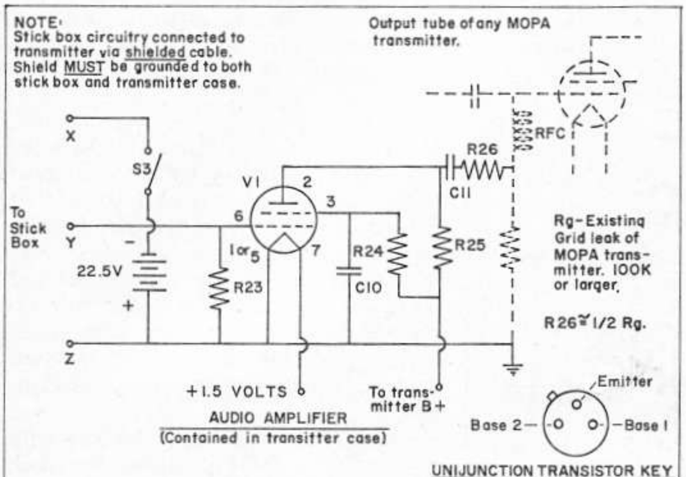
PROPORTIONAL SYSTEM

SECOND OF THREE PARTS OF 1962 TOP INTERMEDIATE SYSTEM—THIS AMAZINGLY COMPLETE PROJECT IS THE BEST RADIO CONTROL PRESENTATION BY M.A.N.

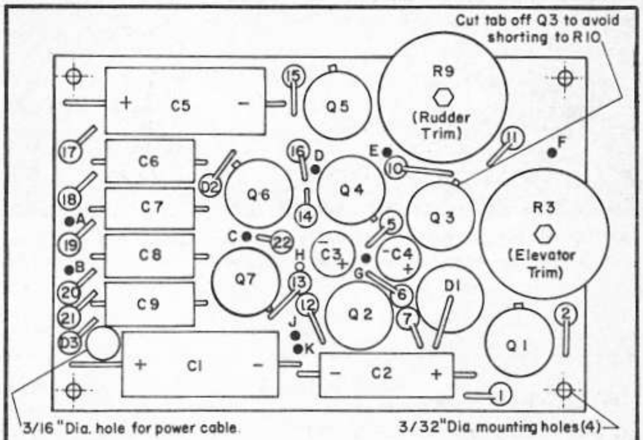


MODIFICATIONS TO "PROTOL" STICK ASS'Y
(views are toward shaft side of R4 and R8)





UNIJUNCTION TRANSISTOR KEY
(Bottom view)



COMPONENT LAYOUT

For clarity, power, signal, and control cable wires are not shown. The cable passes through the 3/16" Dia. hole from the conductor side of the circuit board and the wires terminate on the component side. The small dots on the component layout indicate wire terminations, and the letters indicate the function of the wire by the following code:

A- To S1 and S2, ground side.
B- To plus 22.5 Volts ("Z" and ground on schematic).
C- Signal output to grid of V1. ("Y" on schematic).
D- To S2 ("Slow throttle switch).
E- To R8 ("Rudder pot.")
F- To R4 ("Elevator pot.")
G- To R4
H- To S1 ("Fast throttle switch)
J- To R8
K- To minus 22.5 volts through S3 ("X" on schematics).

Diodes D1, D2, D3, are inserted with cathode lead toward board.

SEE PAGE 72 FOR CHANGES, MODIFICATIONS AND ADDITIONS PARTS ONE AND TWO OF THE B & D SYSTEM.

and we expect it to become a "standard" whenever its merits become more widely known. We have taken some liberties with Mr. Phelps's circuit, but only to adapt it to our system.

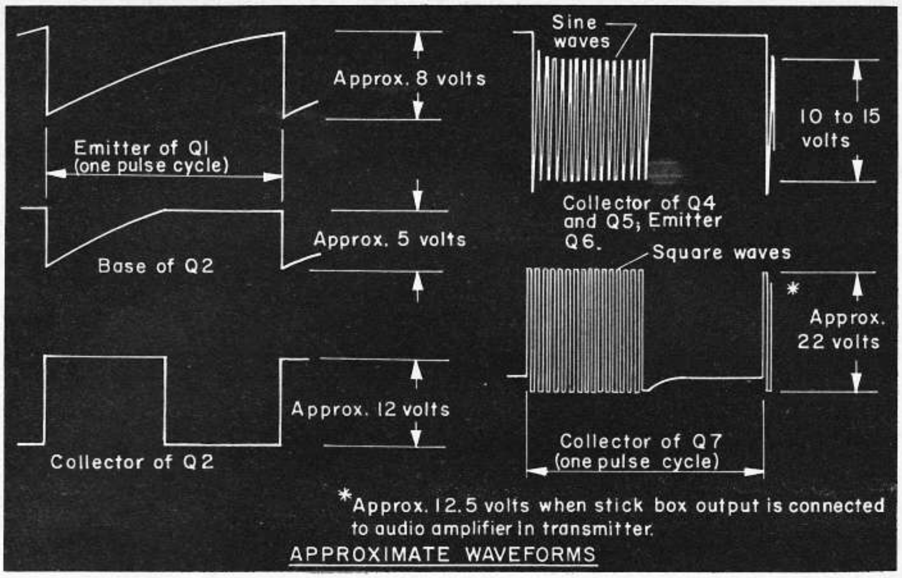
The tone generator is a phase-shift oscillator with an emitter follower impedance matching stage (Q6) to make it more tolerant of transistor variations. The clipper amplifier and voltage amplifiers are common circuits and need no elaboration except for the purpose of R26. The output of V1 is approximately 120 volts peak to peak which is considerably greater than required to 100% modulate most transmitters. Some transmitter output tubes can be damaged by too great a negative grid voltage swing, particularly if the B-plus voltage runs above 150 volts or so. Therefore, R26 is included to reduce the modulating voltage as seen by the grid of the transmitter output tube. R26 should be about one-half the value of Rg. (Rg is the existing grid leak of the transmitter you intend to use and will likely be between 100K and 2.2 megs. If Rg is found to be less than 100K, increase it to 100K.)

We lack space for a detailed analysis of circuit operation. However, readers with a basic knowledge of solid state electronics will have no difficulty determining how the circuit works except possibly for the function of Q3, C4, and R5. These parts comprise a "compensating circuit" which introduces a slight interaction such that the percentage of tone "on" time of each pulse automatically decreases as pulse rate is increased and vice versa. This action balances out an opposite and unavoidable interaction introduced in the receiver by the filter capacitor C6 (receiver schematic). The net result is that there is no discernable interaction between the rudder and elevator other than mentioned in Part I. Without the compensating circuit, the rudder will vary a couple of degrees as the elevator is varied from one extreme to the other. The resistor R6 determines the amount of compensating interaction. The value specified for R6 will be correct for the majority of situations. However, it is possible for normal component tolerances to combine in such a manner that a slightly different value will be required to keep the rudder in "dead center" when the elevator is moved from one extreme to the other. If full up (high pulse rate) produces a slight amount of left rudder and full down a bit of right rudder, increases R6 to the next larger value. It is extremely unlikely that up elevator will produce right rudder, but if it does occur, the cure is to reduce R6. Any change in R6 will require repetition of the entire adjustment procedure described later.

If the reader wishes to use the P/M with other (*Continued on next page*)

B & D PROPORTIONAL SYSTEM CONTINUED

systems and has a receiver that is free of interaction; Q3, C4, and R5 should be omitted and R11 connected directly to ground. The pulse rate can be lowered by increasing R3, R4, R6, and C2. (Do not increase C2 beyond 10 Mfd.) For any give neutral pulse rate, the percentage of rate change with stick motion may be increased by increasing R4 and vice versa. The maximum pulse width ratio may be increased by decreasing R11 and/or by increasing R8. Both rudder and elevator trim sensitivity can be increased by increasing R5 and the parallel combination R9/R10. (R10 can merely be omitted to increase elevator trim sensitivity.) The tone generator frequency can be decreased by increasing R18 and R19 and vice versa.



APPROXIMATE WAVEFORMS

Many circuits were evaluated and discarded and a great deal of effort was expended in the development of this pulser-modulator to make it as foolproof and versatile as possible. The reader is cautioned to follow instructions explicitly and to avoid parts substitutions. Deviations can cause real difficulty. For example, if shielded cable is not used for connecting the P/M to the transmitter, or if the shield is not connected to ground, the RF from the transmitter may cause improper operation. If a wide tolerance electrolytic is substituted for the 10% tantalum, C2, the pulse frequency range will likely be affected. If ceramic capacitors are substituted for C6, C7, and C8 instead of the specified Mylar, tone instability with temperature will result.

Start construction by cleaning and checking the transmitter you intend to use. The old modulator can be stripped out and the audio amplifier substituted, or the old modulator can be retained for use with other control systems and the audio amplifier located elsewhere in the transmitter case. (In the latter event, a SPDT switch can be used to select the output of the desired modulator). Because of the variations in transmitters, no mechanical details are given for the audio amplifier. The electrical layout is simple and non-critical; just keep it out of close proximity to tuning coils or other "hot" parts of the transmitter. If your transmitter doesn't have an RF choke between the grid of the output tube and the grid leak resistor as shown in the schematics, be sure to add one. For 27 mc and 50 mc "doubler" type transmitters, the 100 microhentry "National" R33 and 20 microhenry "Miller" 6152 respectively are recommended. For 27 mc. transmitters that do not double the oscillator frequency in the final stage, such as the "WAG," use the Miller 6152. Incidentally, the MOPA doubler type transmitters are much to be preferred because they have much less tendency to "swamp" the receiver at close range.

The 22.5 volt battery is also located in the transmitter case. We use a Burgess type 4156 or equivalent. A battery this size will last an entire flying season since the average drain is only about 9 ma.

Drill the holes in the circuit board and assemble the components using the general procedures described in Part I. Include the various wire leads (Bonner wire) but omit R11 at this time. Some of the conductors on the circuit board are quite close together, so use great care to prevent solder bridge overs. After assembly, remove the flux with lacquer thinner using great care not to contaminate the trim pots, and examine the board for cold solder joints.

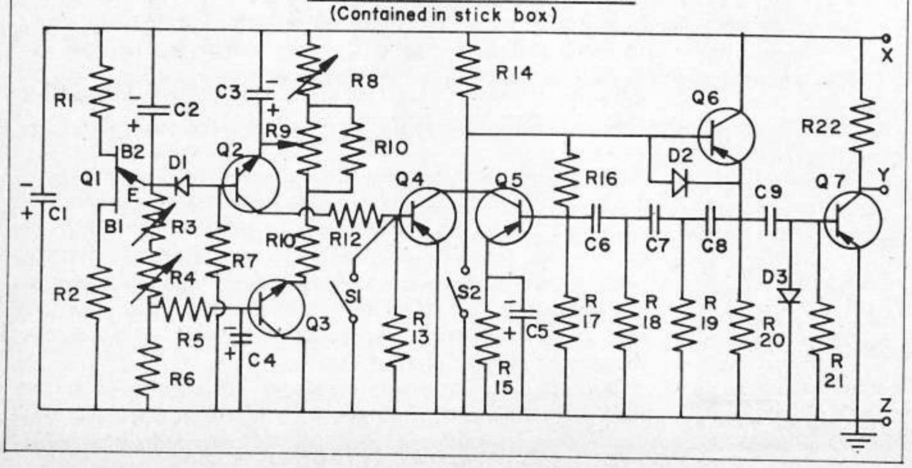
If you have built up the transistor checker described in Part I, check the transistors and use those with the lowest gain, lowest leakage at Q2, Q7 and Q4. Use the highest gain at Q5. Selection isn't mandatory, but it will enhance the high and low temperature operation of the P/M. The unijunction transistor, Q1, cannot be tested.

Drill the required holes in the case and cut out the stick opening. Modify the "Protrol" primary and secondary plates as shown in the drawings. Cut the shafts of R4 and R8 to 9/16 and 7/16 inch in length respectively. Assemble the "Protrol" and adjust all stick stops to the extreme positions except the up elevator stop which should be removed (to facilitate spins!).

Assemble the box but do not connect the circuit board leads to the plug, pots, and switches until it is certain that all parts have the proper fit and alignment. Correct any interference between the box covers and the screw heads and plug with a file and be sure that the stick clears the box cover at all exreme positions. A 3/16 inch diameter screwdriver hole drilled in the case opposite each pot shaft set screw will facilitate mechanical adjustment of the pots during electrical check out.

The circuit board leads may now be routed neatly along the lower right hand corner of the box, terminated at the proper places, and tied with soft cotton string or ribbon at one inch intervals. Leave bundles sufficiently long for later removal of the circuit board and for "flexing" of the leads to R4.

PULSER AND TONE GENERATOR
(Contained in stick box)



Make up the (*Continued on page* 52)

Pulse/Modulator

(*Continued from page* 22)

the connecting cable to the transmitter. Be sure to use strain relieving clamps at each end. We found it necessary to fasten the clamps to the connector shells with ¼x 2-56 screws to prevent the clamp from turning inside the shell. The shield is used for the ground conductor (plus 22.5 volts). To "pigtail' the shield for termination simply unbraid it for about 1½ inches, cut off about two-thirds of the strands, and twist the remainder together.

Now, check the entire wiring against the schematic and correct any errors.

Preliminary electrical check-out is best made with an oscilloscope and signal generator. Tack in about 10K for R11. Apply power to the P/M (leave transmitter off) and observe the output between the grid of VI and ground with an oscilloscope. Both trims pots should be centered during this operation. Loosen the set screw of R8 and rotate the shaft until the waveform looks like that illustrated for the "collector of Q7.". With the stick at neutral, tighten the set screw.

Now connect an audio signal generator to the oscilloscope horizontal input, adjust its frequency to 40 cps, and set the scope horizontal selector switch to "external input." A figure resembling a revolving disc viewed from the edge with a picket fence built half way around the periphery should appear. (The picket fence is the tone frequency.) Loosen the set screw of R4 and rotate the shaft until the disc stops rotating and only one picket fence is in evidence. This "Lissajous Figure" indicates that the pulser and signal generator frequencies are identical, namely 40 cps.

Determine the maximum available pulse rate range by applying full down stick (don't touch trim—keep both trim pots centered) and adjusting the signal generator frequency until the "picket fence" stops rotating. This should occur between 31 to 33 cps. The same procedure applied for full up stick should yield about 48 to 52 cps. The above range is almost certain to be obtained with the value of C2 specified. However, it is possible that normal parts tolerances may combine in such a direction that a smaller value of C2 will be required. (The authors use a rate range of 32, 38, and 48 cps respectively for down neutral and up elev.)

Now set the 'scope horizontal selector switch back to normal internal sweep operation and if necessary, readjust the neutral setting of R8 for a 50/50 pulse width ratio as before. Move the stick from one rudder extreme to the other and observe the pulse width ratio. If it varies from 70/30 to 30/70 or slightly less, R11 may be installed permanently. If a greater variation is obtained, increase R11, if smaller than 65/35 to 35/65, reduce R11. R11 will likely fall between 5.6K and 10K. Please bear in mind that the neutral setting of R8 will have to be readjusted to obtain a 50/50 PWR at neutral each time R11 is changed.

Whenever the fast throttle switch is closed, solid tone should appear. The frequency should be between 1250 and 1500 cps. The frequency can be checked by the "Lissajous Figure" method on the scope if desired. Whenever the slow throttle switch is closed, no output should appear; just a straight horizontal line.

The pulser-modulator is now adjusted except for minute neutral adjustments that may be required to match it to the receiver. The above procedure may sound complicated, but it really is quite simple. Assuming the P-M is properly wired and no parts are defective, the entire procedure can be performed in less than 30 minutes. The experimentally determined values of R11 and in some isolated cases, R6 and C2, are permanent; once determined, they will never have to be changed.

If there is no output, or the circuit otherwise malfunctions, have a friend double check the wiring for you—use the illustrated waveforms as an aid in isolating the trouble. This is a sure fire circuit and can be counted on to work if properly wired and no parts are defective.

If all is well, the time has come to fire up the transmitter and check receiver operation. The receiver should first be tuned to the transmitter frequency by the method discussed in Part I and the receiver waveforms checked against those illustrated. The pulse omission detector relay should pull in whenever the high or low speed throttle switches are closed, and if a Mighty Midget is connected to the motor control servo amplifier output, it should rotate one direction for high speed and the other for low speed. *Caution! Don't use motor of less than 5 ohms.*

A D. C. voltmeter connected between the pluse 2.4 volt servo battery tap and the rudder filter output as described in Part I should read close to zero volts. Adjust the neutral setting of the rudder pot shaft (R8) to "zero in." Now move the stick to one extreme rudder position and then the other. The filter output should vary plus and minus .5 to .6 volts. The rudder trim pot should produce a change of plus or minus .1 to .2 volts.

Now connect the D.C. voltmeter to the elevator filter output and "zero in" the elevator filter by adjusting the neutral setting of the elevator pot, R4. Moving the stick to extreme down and to extreme up should produce a change of plus .3 to .4 and minus .5 to .6 volts respectively. The elevator trim pot should produce a change of plus or minus .1 to .2 volts.

It may be necessary to adjust the rudder stick stops so that the stick travels slightly further left than right to obtain equal output about neutral from the rudder filter. This slight lack of linearity is negligible. A greater lack of linearity is inherent in the elevator and it is sufficient to be detrimental unless your airplane likes more "up" elevator than down. This originates in the pulser, but fortunately, it can be canceled at the airplane end by the addition of a 1.8K resistor between the wiper and the plus 4.8 volts lugs of the *elevator servo* pot. (1.2K if Space Control servos are used.) If your airplane likes more down than up elevator, it is preferred that R3 and R4 be connected in reverse of the drawings and fast rate be used for down rather than to overcompensate at the servo. R3 is reversed

(*Continued on page* 56)

Pulse/Modulator

(*Continued from page 53*)

by cutting away the copper on the circuit board which shorts the wiper to the bottom lug of R3 and soldering a shorting wire between the wiper and the top lug.

To facilitate spins, a "spin-button" may be added to the stick box. This consists of a N.O. push button switch in series with a resistor connected across the active lugs of R4. Pushing the button increases the pulse rate beyond 50 cps and gives an abnormal amount of up elevator. The resistor will be somewhere between 4.7K and 10K and is determined by trial and error to obtain the desired amount of up. If the elevator pots are reversed as per the preceding paragraph, a different arrangement must be used. A resistor can be connected in *series* with R4 and a normally closed push button switch in *parallel* with the resistor. Pushing the button will then give an abnormal amount of up by slowing the pulse rate. The limitation here is that the rate not be slowed to the point that the receiver pulse omission detector relay chatters. The spin-button is an optional feature, of course.

The throttle switches shown on the drawing are miniature snap-action "micro" type switches. The aluminum throttle lever requires no spring loading; it is returned to the center position by the spring action of the switches. The throttle lever must move freely and without binding. The purpose of the switch lever guide strip is to keep the lever from raking against the opening in the top of the box. A tiny amount of grease smeared on the switch lever at the point of contact with the guide strip will prevent the aluminum from galling. The pivot at the bottom end of the lever is simply a piece of 3/32 I.D. brass tubing cut slightly longer than the thickness of the lever and fastened to the box with a 2-56 machine screw and nut.

If desired, the entire throttle switch installation as shown on the drawings may be replaced with two push button switches. The push button arrangement is more simple, less expensive, and will work almost as well. The switches may be mounted two on the left side, two on the right side, or one on each side as preferred. It is purely a matter of individual preference, and each builder should hold the box in his hand and determine the most convenient location for him. If both switches are mounted on the right side, it will probably be necessary to assemble the "Protrol" stick assembly in "mirror reverse" order to that shown on the drawing to avoid interference between the switches and the secondary plate.

If you are a southpaw, the box can very easily be built "left handed.' This will require locating the trim pot openings on the right hand side of the box and about ⅛ inch further from the front, turning the circuit board around so that the component side faces rearward, and connecting R8 opposite to the drawing. With this arrangement, full left rudder will correspond to 30% tone on rather than 70% but it makes no difference. As explained in the next installment, the servos can be wired to rotate in either direction with respect to stick motion.

If you own a couple of "Space Control" servos you are now in business. Otherwise, wait until next month when we will describe the muscle end of this system in the concluding article of the series.

As a last thought, it is not necessary to use a headset or meter for tuning in the field. Just have someone hold the stick in full up and tune at about ¼ mile. Set the slug in the middle of the range in which the elevator will stay in the up position.

(*Continued on page 57*)

PARTS LIST
PULSE/MODULATOR

R1 10 ohm	**R12** 47 K	**R19** 3.3 K	**R26**—See text.
R2 100 ohm	**R13** 2.2 K	**R20** 10 K	
R5 39 K	**R14** 18 K	**R21** 2.2 K	
R6 1.2 K	**R15** 2.2 K	**R22** 39 K	
R7 1 Meg	**R16** 220 K	**R23** 47 K	
R10 3.3 K	**R17** 39 K	**R24** 100 K (½ Watt)	
R11 see text	**R18** 3.9 K	**R25** 100 K (½ Watt)	

All fixed resistors, carbon, ¼ Watt except where specified otherwise, "Ohmite," (Allied) (½ Watt can be used throughout). All resistors, 10%.

R3 1 K variable, linear taper, Centralab type **B16-109** (Newark)
R9 2.5 K variable, linear taper, Centralab type **B16-111** (Newark)
R4 10 K variable, linear taper, Ohmite type **CU1031** (Allied)
R8 25 K variable, linear taper, Ohmite type **CU2531** (Allied)
C1 50 Mfd, 25 VDC, Sprague type **TE 1209** (Allied)
C5 25 Mfd, 25 VDC, Sprague type **TE 1207** (Allied)
C2 5.6 Mfd, 35 VDC tantalum, Texas Instrument type **565BP035A2** (Allied)
C3 4.0 Mfd, 25 VDC "IEI" printed circuit type (Ace)
C4 1.0 Mfd, 25 VDC "IEI" printed circuit type (Ace)
C6, C7, C8 .01 Mfd Mylar, Cornell-Dubilier type **WMF 1S1** (Allied)
C9 .033 Mfd Mylar, Cornell-Dubilier type **WMF 1S33** (Allied)
C10, C11 .1 Mfd paper or Mylar, 400 VDC or higher, any brand.
D1 1N1692 **silicon** rectifier, General Electric (Allied)
D2, D3 1N34A, 1N66A, or other general purpose germanium diode.
Q1 2N1671 unijunction transistor, General Electric (Allied)
Q2, Q3 2N1302 or 2N1304 NPN transistor, Texas Instrument (Allied)
Q4, Q5, Q6, Q7 2N1303 or 2N1305 PNP transistor, Texas Instrument (Allied)
V1 1U4 or 1L4 tube (Allied)
S1, S2 Subminiature snap action switch, Unimax type **1SM1** (Allied)
OR SPST N.O. push button switch, Switchcraft type **101** (Allied) or equivalent (Ace)
S3 SPST toggle switch, any good brand.
1—7 pin miniature tube socket
1—8 pin Octal socket, Amphenol type **78S8** (Allied)
1—8 pin multi-wire connector, female, Amphenol type **78-PF8** (Allied)
1—8 pin multi-wire connector, male, Amphenol type **86-PM8** (Allied)
1—8 pin plug, Amphenol type **86-CP8** (Allied)
2—cable clamps, Amphenol type **79-CC4** (Allied)
7.5 ft.—shielded two conductor microphone cable, Belden type **8413** or **8420** (the shield serves as the ground conductor) (Allied)
1—printed circuit board (Ace)
1—Stick Assembly, "Protrol," dual channel type (Ace)
1—Aluminum utility box, 2x3x5, (Ace)
*1—3/16 x ¼ x 2¼ aluminum or ¼ sq. x 2¼ maple (throttle lever)
4—⅛ ID x 3/16 OD x 1 Alum. or brass spacers
4—3/32 ID x ⅛ OD x ⅝ Alum. or brass spacers
*1—.020 x ¼ x 1¼ brass strip
4—4-40 x 1¼ machine screws and nuts
4—2-56 x 1 machine screws and nuts
*5—2-56 x ½ machine screws and nuts

* Omit if push button throttle switches are used.

Components Notes: The Texas Instruments tantalum capacitors, C10 and C12, are carried in the 1963 Allied Industrial Catalog under type number 475FP010A4. Some parts with Allied listed as the source will not be found in Allied's general catalog but can be ordered from their industrial catalog which can be obtained from them for the asking.

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Allied Electronics Corp., 100 N. Western Ave., Chicago 80, Ill.
Newark Electronics Corp., 223 W. Madison St., Chicago 6, Ill.