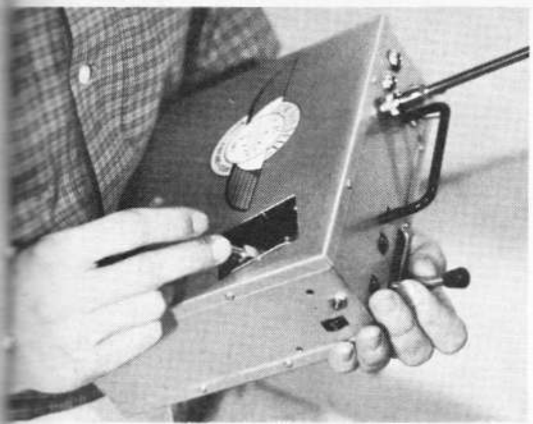
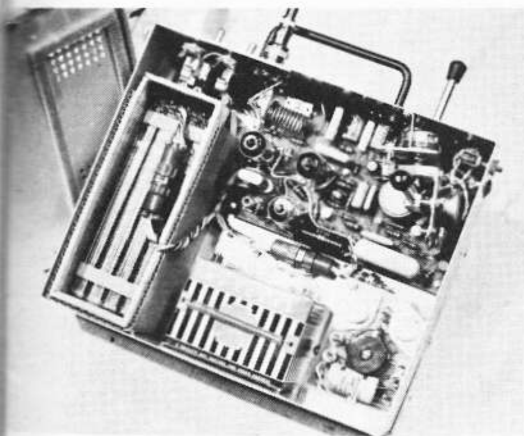
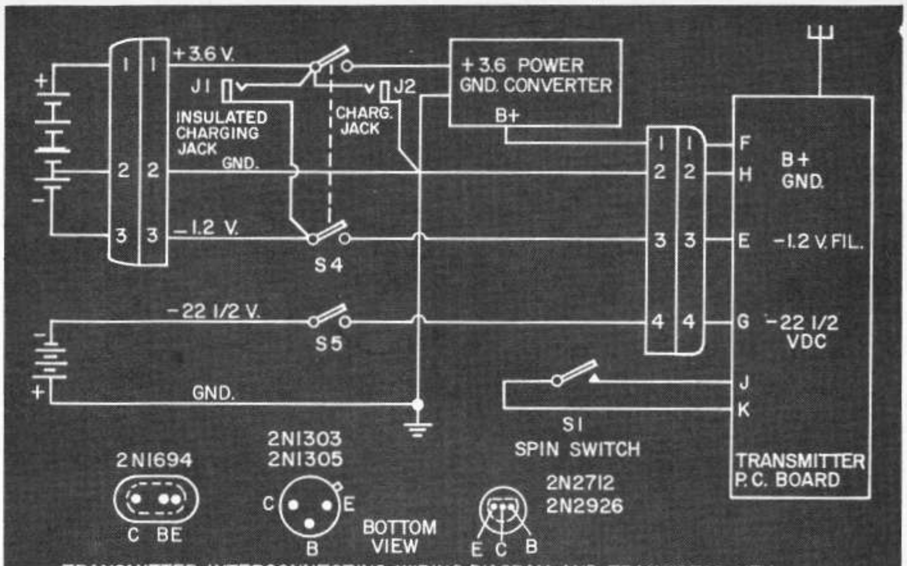
by DON DICKERSON & NORM BEELER



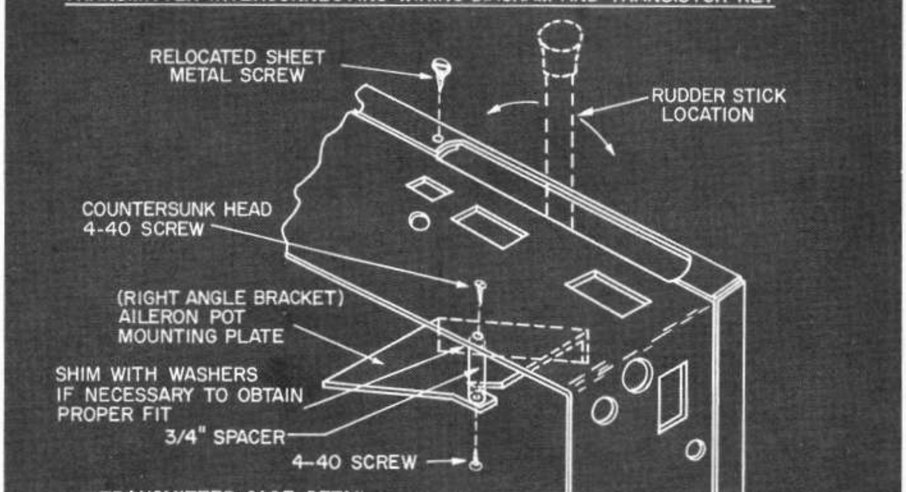
Transmitter in flying position showing novel stick arrangement, stick on top is for rudder control.



The inside story. Plenty of room for dry or wet power supplies. Connectors facilitate removal of the major components. Converter lower right.



TRANSMITTER INTERCONNECTING WIRING DIAGRAM AND TRANSISTOR KEY



TRANSMITTER CASE DETAIL

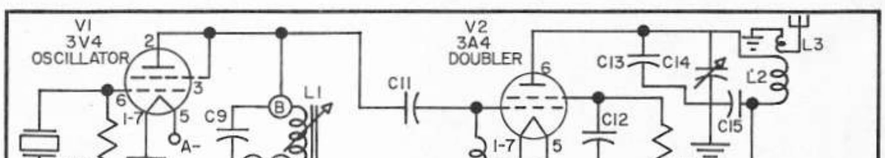
B & D PROPORTIONAL TRANSMITTER

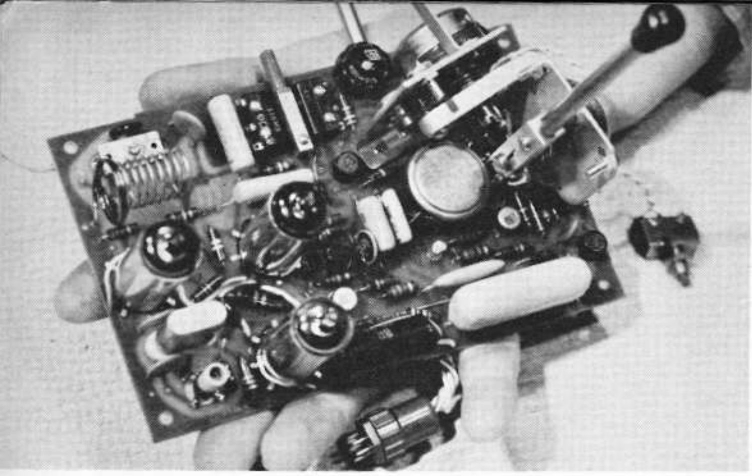
PART ONE—SERIES 2

THIS NEW B&D PROPORTIONAL SERIES IS STRICTLY BY POPULAR DEMAND — DON'T KNOW OF ANY OTHER SERIES OF M.A.N. ARTICLES WHERE WE HAVE HAD AS MANY READER REQUESTS TO RUN A FEATURE.

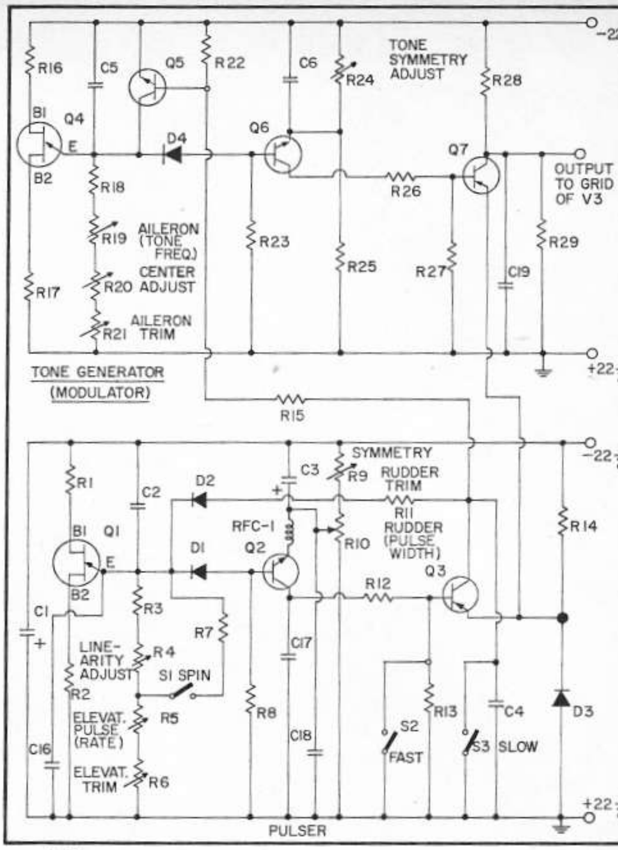
► This transmitter is for use with the "B & D Pulsatone" dual simultaneous feedback proportional control system which appeared in the March, April, and May, 1963, issues of M. A. N. Provision for operation of a third proportional control via variation of the modulation frequency is an integral feature. (The third proportional control discriminator and servo will be described in next month's issue). Its usefulness is not necessarily limited to the B & D system. With a few simple modifications, it can be used for most any pulse-rate, pulse-width system such as Kicking Duck and Simpl-Simul, or for simple single channel proportional or escapement flying. Size is 3 x 8 x 9¾" and total weight is 5½ pounds. Total retail cost for all parts, including the power supply is approximately $80.

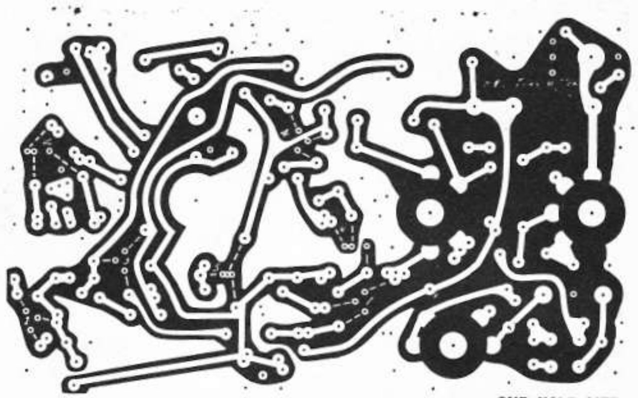
As the photos indicate, the transmitter features a unique two-stick control arrangement. To operate, the transmitter is cradled in the left arm as shown, the rudder stick, throttle, "spin button," and all trim functions are operated with the left hand. The right hand remains completely free to operate the other stick which controls the ailerons and elevators and never has to be removed from the stick to (*Continued on next page*)





Integrated component board easily removed for maintenance/adjustment. 52 mc version shown.





PRINTED CIRCUIT BOARD HOLE SCHEDULE — ONE HALF SIZE

MOUNTING HOLES (5) 1/8 DIA.
CRYSTAL SOCKET (3) "
MOUNTING, RIGHT ANGLE BRACKET (3) "
R10 KEY LUG (1) "
R10 SHAFT (1) 3/8 DIA.
R5 LEAD WIRES (1) 1/8 "
" " " (1) 1/16 "
V1, V2, AND V3 SOCKETS (3) 11/16 DIA.
ALL OTHER HOLES #60 DRILL (.040)

POWER CABLE (1) 3/16 DIA.
C14 LUG & ADJUST SCREW (3) 11/64 DIA.
(2) 5/64 DIA.
L1 (4) 5/64 DIA.
L2 AND L3 (4) #54 DRILL (.055)
S2 AND S3 AND THROTTLE LEVER PIVOT (5) 3/32 DIA.
R6, R9, & R2 MOUNTING AND LUGS (15) 3/32 DIA.
R6, R9, & R2 SHAFT (3) 3/16 DIA.

B&D PROPORTIONAL X-MITTER

operate throttle or trim, a feature we like very much. The fore and aft axis of the aileron/elevator stick is slanted 15 degrees to the vertical which we find to be more natural and comfortable than the usual perpendicular arrangement.

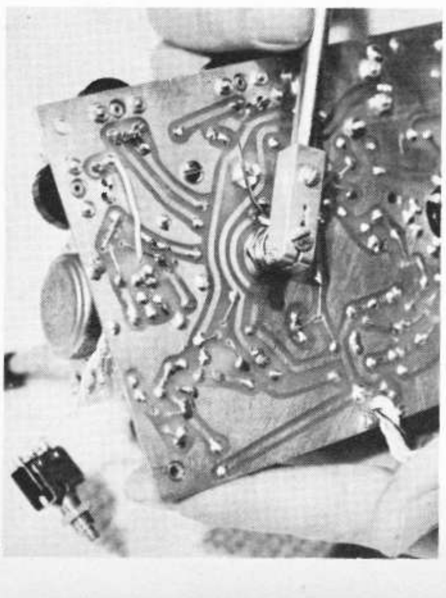
An optional "spin button" is located on the upper R.H. side of the transmitter. When pressed, the pulse rate increases and an abnormal amount of up elevator is available for *really* snappy snap rolls and ease of spin entry. The spin button has maximum effect with the stick in full up position and very little effect with the stick in full down.

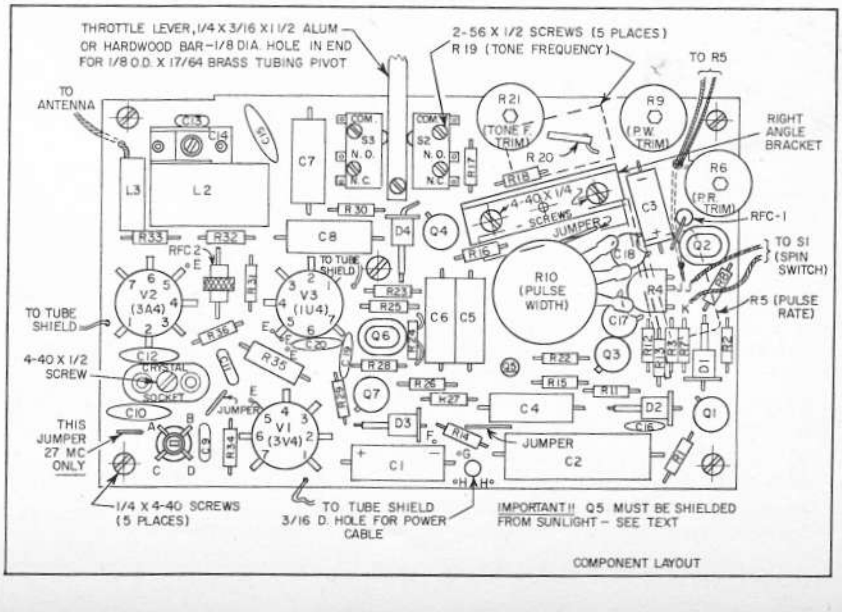
Electrically, a conventional MOPA tube type RF section and audio amplifier are employed in conjunction with a transistorized pulser and tone generator. The input to the 3A4 class "C" R.F. amplifier-doubler stage is about 1.5 watts. We do not know the actual R.F. output but will venture a guess of about ½ watt. Obviously, it isn't exactly a power-house, but a range of at least ¼ of a mile can be expected with a properly set-up B&D receiver in either the 27 mc. or 52 mc. versions.

A 58 in. quarter-wave antenna is used for the 52 mc. transmitter and a 58 in. *center loaded* antenna for the 27 mc. transmitter. If you do not use the center loaded antenna on 27 mc., you are strictly on your own. Our tests indicate considerably increased output with the center load and since this transmitter is not a high power job, it is advisable to radiate the R.F. efficiently. One can either build the center load described in the drawings or purchase the commercial center loaded antenna in the parts list. Suggested reading on this subject is an article by Dale Springstead in the Sept.-Oct., 1963 issue of Grid Leaks magazine.

Total "B" drain at 135 volts (*Continued on page 35*)

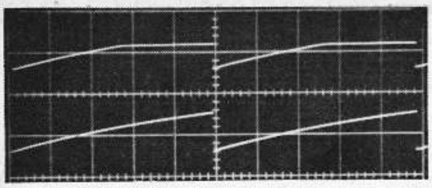
Back of component board showing Protol rudder stick arrangement. Spin control switch at left.



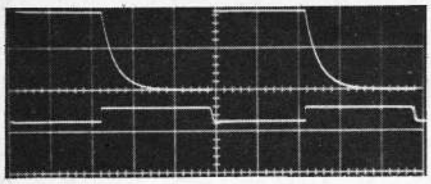


COMPONENT LAYOUT

WAVEFORMS

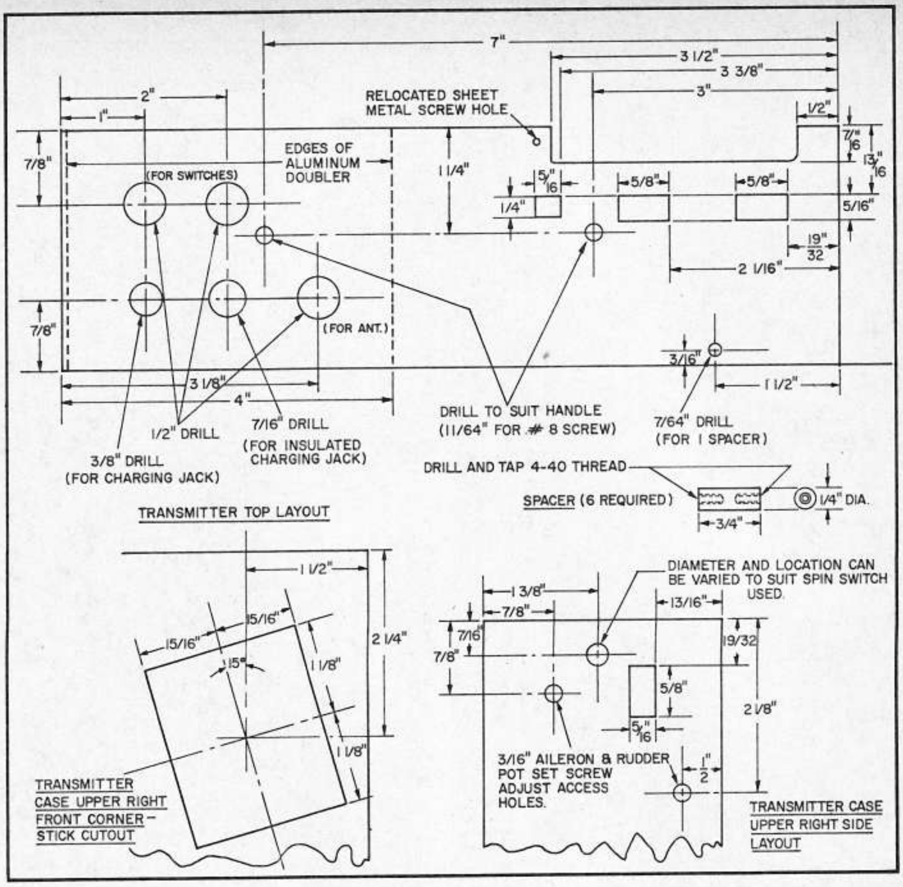


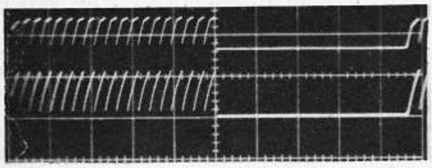
TOP—BASE OF Q2
BOT.—EMITTER OF Q1
HORIZ.—TWO PULSE CYCLES
VERT.—10 VOLTS/DIV.



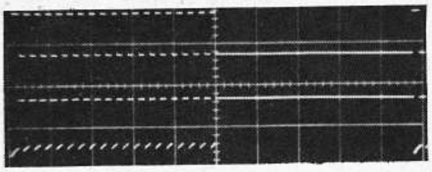
TOP—COLLECTOR OF Q3
BOT.—COLLECTOR OF Q2
HORIZ.—TWO PULSE CYCLES
VERT.—10 VOLTS/DIV.

MODULATED RF OUTPUT VIEWED BETWEEN ANTENNA TERMINAL AND CASE. SEE TEXT.
HORIZ.—ONE PULSE CYCLE

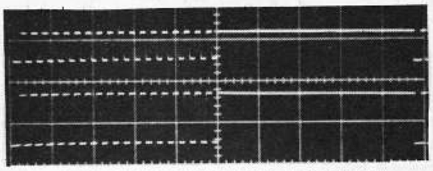




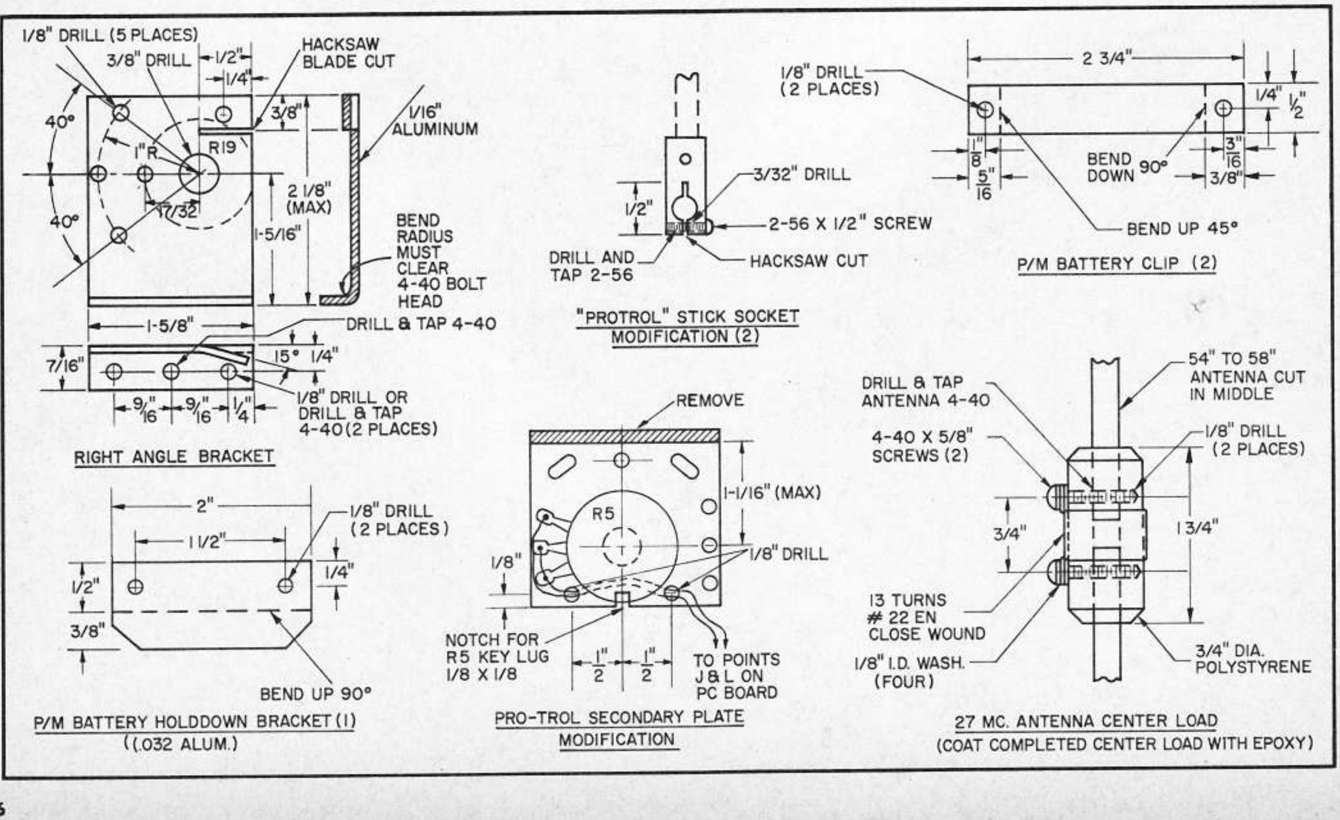
TOP—BASE OF Q6
BOT.—EMITTER OF Q4
HORIZ.—ONE PULSE CYCLE
VERT.—10 VOLTS/DIV.



TOP—COLLECTOR OF Q7
BOT.—COLLECTOR OF Q6
HORIZ.—ONE PULSE CYCLE
VERT.—5 VOLTS/DIV.



TOP—JUNCTION OF R32, R33, AND RFC-2
BOT.—PLATE OF V3
HORIZ.—ONE PULSE CYCLE
VERT.—100 VOLTS/DIV.



B&D Proportional Transmitter

(*Continued from page* 28)

averages about 20 ma. and the filaments draw 350 ma. We use four surplus 4 amp. hour Nicads, one for filament and three for the 3.6V input to an Ace A3.6CK power converter. Some writers have cautioned against using a single 1.25 volt Nicad for transmitter filaments, but, in fact, our tests did not indicate any increase in output by raising the filaments to above 1.25 volts. If a separate single Nicad is used and kept at the top of its charge, no difficulty should be experienced.

Any power converter capable of supplying 135 to 150 volts at 22 ma. should be satisfactory. The low cost Ace converter has worked well for us. Efficiency is 60% and drain on the Nicads is about 1.4 amps. Therefore, to stay on the safe side, 4 amp-hr. cells should be charged after no more than two hours operation. If desired, dry batteries may be used in place of the Nicads and power converter. There is plenty of room in the case for them.

CAUTION! NEVER charge non-sealed type Nicads while they are installed in the transmitter. The resulting gassing and splatter of electrolyte will surely ruin the case. Always remove them for charging, let them gas off, and wash them under running tap water before reinstalling. As a further protection against corrosion, the cells may be contained within the transmitter in an open fronted doped corrugated cardboard compartment, the cover drilled for air circulation, and adhesive backed foam rubber weather stripping stuck to the cover for a gasket as shown in the photos. Epoxy varnish or plastic cement applied to the battery terminals will protect the wire terminations. To facilitate the necessarily frequent front cover removal, the screw holes are converted to slots with a file so that the screws need merely be loosened a half turn to remove the cover. Of course, if one can afford them, 4amp. hr. or larger sealed sintered plate Nicads will make a superior installation.

The pulser modulator circuit is considerably different from the one described in the April, 1963 M.A.N., and is superior in every respect. The old pulser modulator, proved unsuitable for the extra channel, but if you have one, most of the parts can be salvaged for the new pulser modulator. The new circuit is essentially two Phelps pulsers, one which oscillates at the pulse frequency of 32 to 48 c.p.s., and another which oscillates at the tone frequency of 1440 to 1560 c.p.s. The low frequency pulser switches the tone generator on and off at the pulse frequency. An increase in tone frequency gives right aileron, increased pulse frequency up elevator, and increased percentage of tone "on" left rudder.

Some outstanding features of the new pulser modulator circuit are nearly perfect linearity of all control functions, and the ability to operate over extreme temperature ranges with negligibly small variations in pulse rate and width and tone frequency. Over a temperature range of 35 to 120 degrees F., pulse rate can be expected to remain constant within ½ cycle, pulse width within 2 per cent, and modulation frequency within 10 cycles, or .66 per cent. Operation will continue beyond 175 degrees F., but at that temperature, a bit of trim change will be necessary! On the opposite extreme, operation will continue down to 10 degrees F., but since we freeze up at about 40 degrees, no effort was made to obtain figures at that temperature.

Such excellent temperature characteris-

(*Continued on page* 38)

B&D Proportional

(*Continued from page* 35)

tics were obtained by use of Mylar capacitors for all critical timing applications, inexpensive silicon or low leakage rate-grown germanium transistors for NPN positions, and by reverse biasing of PNP germanium switching transistors via R4 and D3. This should be sufficient word to the wise, but we repeat our warning from the earlier series, don't substitute parts unless you have sufficient experience to know exactly what you are doing!

The pulser modulator draws approximately 10 ma. from the 22½v. battery. The battery should be discarded after the voltage under load drops to a minimum of 16 volts. Happily, this much voltage change has negligible effect on pulse rate and width and tone frequency.

Let's take a look at the pulser modulator circuit and see how it works. First, completely disregard capacitors C16, 17, 18 and 19, and RFC1. These components are used for radio frequency interference (RFI) suppression and are not essential to the theory of operation of the circuit (more on RFI later). Q1, C2, and the resistor string R3, 4, 5, and 6, form a simple unijunction sawtooth oscillator. Q2 is a comparator stage which is normally biased "on" by R8, except when diode D1 is forward biased which occurs when the voltage of the sawtooth waveform is more negative than the emitter of Q2. Q2's emitter voltage is determined by the setting of the rudder stick pot, R10, in the voltage divider string R9 and R10. Therefore, Q2 can be more to fire (turn on) at any point on the slope of the sawtooth oscillator waveform and thus determine the pulse width ratio. At the end of a pulse cycle, Q2 will immediately turn off as Q2 discharges thru the emitter of Q1 and current limiting resistor R1. Q2 is directly coupled by R12 to the switch stage Q3, which in turn, is direct coupled through R15 to another switch, Q5. When Q2 is OFF, Q3 and Q5 are also OFF and vice versa.

When Q2, Q3 and Q5 are OFF the tone generator operates precisely the same as the pulser, except at 1440 to 1560 c.p.s. and the tone symmetry is permanently set to 50/50 and not used for control purposes. Whenever Q2, Q3 and Q5 are ON the tone generator timing capacitor C5 is shorted out and oscillation cannot occur. The pulsed tone output of Q7 is fed to the grid of the audio amplifier stage V3. The output of V3 grid modulates the RF amplifier-doubler V2. Modulation is 100%.

The purposes of other components not mentioned above and not obvious from the schematics are as follows: C1 is an AC by-pass around the pulser modulator battery and serves to prevent undersirable interaction or coupling between the pulser and tone generator. D2 and R11 serve to equalize the load on the sawtooth oscillator Q1 and prevents a very slight rate change as pulse width is varied. C3 and C6 are AC by-pass capacitors which sharpen up the waveforms and reduce symmetry drift over the temperature range. C4 distorts one edge of the waveform at the collector of Q3 which, in effect, produces a fixed time delay in the circuit. This causes a very slight interaction such that the percentage of tone ON time decreases very slightly as pulse rate increases to balance an equal and opposite interaction inherent in the B & D receiver. R2 and R17 are temperature compensation resistors that stabilize the pulse and tone frequency. Increasing their value causes the frequency to decrease as temperature increases and vice versa. The values given are for average unijunction transistors and not necessarily ideal in every case, but they are close enough for practical purposes. R29 attenuates the output of Q7 from the normal 22 volts peak to about 6 volts which is more appropriate for the input to the IU4 audio amplifier, V3.

A word of warning. A germanium NPN must not be used for Q5, or tone frequency instability will surely result. The 2N2712 or 2N2629 specified is an epoxy cased economy silicon manufactured by General Electric, and it is perfectly suitable for the application provided it is shielded against impingement from direct light, which would increase the leakage current drastically. So to prevent a snap roll when the sunlight suddenly pours through the stick opening, be *certain* to wrap Q6 in electrical tape, aluminum foil, bubble gum, or some other opague material!!

Start construction by drilling the circuit board (available from Ace) and cutting the holes for the snap-in tube sockets. Before mounting any components, use the drilled PC board as a template for locating the five mounting screw holes and the screwdriver adjust hole for R10 in the back cover. Be sure to have the back cover on the case and the case corner seam oriented to the lower right hand corner for this operation. And, be certain to saw screwdriver slots in the three stick pot shafts before installing them. You are now free to continue construction in any desired order.

Since trimmers are used for all experimentally determined resistor values, all components may be assembled to the P.C. board. It is a good idea to leave power cables sufficiently long to permit initial adjustment outside the case.

The commercial stick assemblies have a few mfr. burrs as they come out of the box, but a little squaring and polishing with a file and wire wheel will make them look nice. Functionally, the "Protrol" can be vastly improved by the use of three turn centering springs and by lubrication of the coils and surfaces that come into contact with them with automotive distributor cam grease. DON'T use oil for this purpose; it will seep back into the pots! We usually loosen the spring tension too, but this is a matter of individual preference. Other modifications to Protrol parts are clearly shown in the drawings. Note that only one Protrol stop is used for the rudder stick, and that is for neutral. It is screwed through the P.C. board from the back into the tapped hole in the right angle aileron pot bracket.

Do not cut the stick opening in the front cover until the integrated circuit board and stick assembly is installed and the dimensions to the elevator-aileron stick vertical center line are confirmed.

Tube shields are not mandatory, but are good practice, particularly on the oscillator. Slip-on shields from an old radio or TV may be used or they can be made by rolling a 2-½" x 1-⅜" piece of tin around a ½-in. dowel. For a neat job, roll about 1/3 the way from one end, and then roll from the other end. We used the tin from a Campbell Tomato Soup can; it worked very well; however we cannot vouch for chicken noodle or clam chowder! Whatever is used, don't forget the necessary step of grounding the shields.

Before performing the electrical adjustments, be sure to check all connections. (Grounding "B" plus and tuning for maximum smoke is not good practice, some say.) Here is the procedure for adjusting the pulser modulator:

(1) Set all trim pots, trimmer resistors, and stick pots to their mechanical centers, except R10 whose tap should be about 2/3 from the ground end.

(2) Apply 22½ volts and with an oscil-

loscope between the collector of Q7 and ground, observe the waveform. A pattern similar to that in the appropriate waveform photo should be obtained, but probably with unequal tone off and on times.

(3) With an audio signal generator set to 38 to 40 c.p.s. sine wave output and connected to the scope horizontal input, switch the scope horizontal selector switch to "external" and adjust R5 until the resulting figure resembling a revolving disk viewed from the edge with a picket fence built part way around stops revolving and with only one fence apparent. Tighten the elev-stick set screw and feed in full-up elevator. Adjust the signal generator until the "lissajous figure" again stops and note the frequency. Do the same for down elevator. If more "up" rate change than down was obtained, adjust the linearity trimmer R4 for a bit less resistance and repeat the entire procedure. If *less* up rate than down is obtained *increase* R4 and repeat the procedure. Continue the process until the up and down rate change is equal while maintaining a center frequency of 38 to 40 c.p.s. Once linearity has been established, check the amount of change in both directions. A rate change of plus and minus 7 to 9 cycles is acceptable. If at least seven cycles is not obtained, parallel C2 with a .25MFD mylar and readjust R4 (not R5) to again obtain 38 to 40 c.p.s. at neutral. This should do the trick. In the unlikely event it doesn't, replace C2 with a 2MFD mylar. It is unlikely that too *much* rate change will be obtained, but if it does the obvious cure is to reduce C2.

(4) With the pulse rate at 38-40 c.p.s., switch the scope horizontal selector back to "internal" and adjust for equal tone on and off time by variation of the neutral setting of R10. From stop to stop, R10 should give a pulse width ratio change of about 30/70 to 70/30. Close S2 (fast throttle) and observe the continuous modulation frequency on the scope. Set the symmetry to 50/50 by means of trimmer R24. Using the "lissajous figure" method, described above, and with the signal generator set to 1500 c.p.s. abjust R20 for a tone frequency of 1500 c.p.s. The correct figure will roughly resemble a stationary rectangle with rounded corners. The aileron stick should produce a change of plus and minus 50 to 60 c.p.s. from neutral to each stop. It at least 50 c.p.s. is not obtained, parallel C5 with an .01 or .022MFD mylar and repeat the procedure. Again, it is not likely that too much change will be obtained. The pulser modulator is now adjusted except for minute neutral changes that may be required to match it to the receiver.

Adjustment of the RF section is so conventional and straightforward that it is hardly worth detailing here. In fact, if the reader isn't sufficiently versed in R.C. to know this procedure, he should not be attempting this project at all. Briefly, the procedure is as follows:

(1) With the P/M off, V2 and V3 removed, and a milliameter in the B-plus lead, tune the oscillator for the "dip" which should occur at 6 to 7 ma. Back the slug of L1 two turns counterclockwise away from the sensitive side of the dip and plug in V2. B-plus current should now be 18 to 24 ma. If it stands at 30 to 40 ma. back the oscillator slug out until the current suddenly dips to the correct value.

(2) Mesh a two turn coil of insulated solid hook-up wire soldered to a number 48 pilot lamp into the coils of L2 and tune C14 until the lamp glows with maximum brilliance (antenna not connected). The 27 mc. version will light a #48 lamp to white brilliance sufficient to obscure the outline of the filament. The 52 mc. version will light the same lamp to white brilliance, but the outline of the filament can be seen.

(3) Finalize the oscillator adjustment by screwing the slug of L1 clock wise into L1 until the lamp goes out, then back the slug out until the lamp again glows plus a quarter turn.

(4) Connect the antenna and install V3. With a field strength meter, adjust C14 for maximum output with the transmitter held in the normal flying position, not setting on the ground or floor. WARNING! The 27 mc. transmitter must be tuned by or under the direct supervision of a person holding a first or second-class commercial radio operator license in accordance with part 95 of FCC Rules and Regulations. And, of course, a general class or technician's class amateur license is required for operation of the 52 mc. transmitter.

If this transmitter is to be adapted for use with other systems, the following information will be useful.

(1) Pulse rate can be lowered by increasing the size of C2. Up to 10MFD may be used. Electrolytics or tantalums can be used since mylars become quite large above 2MFD, but don't expect the temperature stability to be as good. Pulse rate *change* can be increased by a reduction in R3 and R4 and increase in C2 sufficient to obtain the desired neutral rate. C4 may be omitted.

(2) Pulse width change may be increased by increasing the throw of the rudder stick.

(3) Tone frequency may be lowered by increasing C5. If the variable frequency feature isn't desired, the rudder pot, R10, may be moved to the present aileron pot, R19, position and a fixed resistor of equivalent value substituted for R18, 19, 20, and 21.

(*Continued on page* 42)

B&D Proportional

(*Continued from page* 39)

(4) For single channel "push button" operation, a switch or jumper can be added to connect the normally closed contact of S2 to the normally open contact of S3, and S2 used as the key switch. For "tone normally on" operation, the jumper can be from the normally open contact of S2 to the normally closed contact of S3, and S3 used as the key switch.

Difficulties were experienced by some modelers in adapting the original B & D pulser modulator to some transmitters. Probably the most common was with RFI, especially when hand-held transmiters were used. Radio frequency interference is often difficult to measure, analyze, and eliminate. It is caused by the rectifying action of diodes and transistor junctions whenever a transistor circuit is exposed to a radio-frequency field. (i.e., every diode and junction becomes a "crystal set"). RFI usually tends to turn transistors "on" but in come cases it has quite the opposite effect.

It is easy to determine if your P/M is being effected by RFI. Simply connect a scope to the output of your P/M using a 20 micro-henry RF choke in series with your scope positive prove (to prevent "injection" RFI picked up by the scope lead) and observe the waveforms with the RF "off" and again with it "on" and antenna fully extended. Any change in amplitude, pulse or tone frequency or pulse width means you have an RFI problem!! These effects are usually erratic and subject to position of scope leads, body capacity, etc.

Getting rid of the culprit is another story entirely, because the situation can vary so much between different installations. For ground based transmitters connected per the article, RFI can be eliminated by grounding both ends of the connecting cable shield and by inserting 20 micro-henry Miller 6152 Rf chokes in the P/M box in series with the output and minus 22.5 volt leads. If the specified connector was used, the unused connector pins make very convenient terminal points for the RFCs. In addition, .001 Mfd disc ceramic capacitors should be connected between the case ground and the ends of the RFCs electrically nearest the transmitter.

Relief from RFI in hand held transmitters can be obtained by shielding the P/M, preferably in a tight metal box, and/or by using RF chokes and .001 Mfd capacitors to by pass the RFI to ground wherever required. It is good practice to keep all wiring short and as close to the case as practical, and it is not advisable to locate trim pots remotely from the PC board with long wire leads—too much RFI pickup.

RFI effects can usually be localized by checking the P/M stage by stage with a scope, again with the choke in the plus lead, and observing where the effects occur. This is how we located and corrected an RFI problem with this transmitter that was particularly wicked on 52mc. RFC1 and the .001 Mfd capacitors completely eliminated the problem and made the use of RF chokes in the scope lead unnecessary for observing waveforms with the transmitter on. For some unknown reason, the tone generator circuit is unaffected by RFI even though it is similar to the pulser circuit and is located closer to the tank coil. Such is the nature of RFI; we have some theories here but probably can't prove them. Another tip—a grid dip oscillator is particularly useful in localizing RFI effects and determining the frequencies at which they are most troublesome.

Some modelers experienced difficulty in adapting the original P/M to Marcy transmitters that already have a two stage 3A5 audio amplifier. Marcy's amplifier is fine for his system, but totally unsuited to the B & D because it inverts the phase of the modulating voltage at the grid of the RF final stage causing the transmitter to completely leave the air between the tone bursts. In the receiver, what should be a nice quiet interlude between tone bursts becomes a nightmare of superregenerative "hiss" with obviously disastrous results. Cure, of course, is to use the specified single stage audio amplifier.

The third major problem was in using low output transmitters. This coupled with improperly setup insensitive receivers spelled short range. One Canadian correspondent eliminated this difficulty by building a 5 watt powerhouse, and has been happy ever since!

One last tip, the best way (next to a range check!) to check a transmitter for proper overall operation is to observe the radio frequency output directly on an oscilloscope. This is easily done by connecting the transmitter case and the antenna terminal direct to the vertical deflection plates of the oscilloscope cathode ray tube at the socket, by means of *short* wires. *CAUTION!!* Most scopes have to be removed from their cases for access, and some very high voltages exist!! The only scope controls that remain effective with this setup are the horizontal sweep and, of course, focus and intensity. A properly modulated signal will look like the sketch in the waveform photos.

Next month we will describe the third control servo, review the receiving end with respect to correction of most commonly reported difficulties, and present a little surprise bonus.

PARTS LIST

R1, R16—10 ohm.
R2—390 ohm.
R3, R12, R26, R29—10 K.
R7, R30, R31—100 K.
R8, R11, R23—820 K.
R13, R18, R27—6.8 K.
R14, R34—47 K.
R15—22 K.
R17—120 ohm.
R22—2.2 K.
R25—39 K.
R28—27 K.
R32—330 K.
R33—1 Meg.

All fixed resistors 1/4 or 1/2 watt except R35 (Allied)

R35—10 K, 1 Watt, (27 mc.), 3.9 K (52 mc.)
R36—6.8 K
R4, R20—10 K, Trimmer, (Ace 29A14).
R24—25 K, Trimmer, (Ace 29A15).
R5—25 K CCW, Log Taper, Ohmite CB2531.
R10—25 K, Linear, Ohmite CU2531.
R19—3.5 K, Linear, Ohmite CU3521.
R6—5 K, Linear, Centralab B16-113 (Newark).
R9—2.5 K, Linear, Centralab B16-111 (Newark).
R21—500 ohm, Linear, Centralab B16-107 (Newark).
C1—50mf, 25V, Sprague, TE1209.
C2—1.5mf, 100V, Mylar, Mallory 11P5.
C3—5mf, 25V, Sprague, TE1202.
C4, C5, C6—0.068mf, 100V, Mylar, Mallory 1168.
C7, C8—0.1mf, 200V, Mylar, Mallory 201.
C9—33mmf, Mica for 27mc.
C9—5mmf, Mica for 52mc.
C10, C12, C15—0.01mf Ceramic, 200V or greater.
C11—33mmf, Mica.
C13—24mmf, Mica for 27mc.
C13—5mmf, Mica for 52mc.
C14—4 to 40mmf, Trimmer, ARCO 422 for 27mc.
C14—2 to 25mmf, Trimmer, ARCO 421 for 52mc.
C16, C17, C18, C19, C20—0.001mf Disc Ceramic (25V. or greater).
D1, D2, D3, D4—1N536, GE.
Q1, Q4—2N1671, GE Unijunction.
Q2, Q6—2N1694, GE.
Q3, Q7—2N1303 or 2N1305.
Q5—2N2712 (Allied) or 2N2926 (Ace), GE.
V1—3V4.
V2—3A4.
V3—1U4 (1L4 O.K. if R29 is changed to 18 K).
3—Printed circuit board 7 pin tube sockets (Ace 37A63 PCS3).
RFC-1—20 micro Henry Miller 6152 for 27mc (Ace 17A9).
RFC-1—10 micro Henry RCA (ACE 17A8) for 52 mc.
RFC-2—100 micro Henry National R-33 for 27 mc.
RFC-2—20 micro Henry Miller 6152 for 52mc (Ace 17A9).
L1—22 turns No. 28 enameled wire close wound on Cambion No. 2206-2-3 form (Newark) for 27mc.
L1—16½ turns No. 28 enameled wire close wound on Cambion No. 2175-3-3 form (Newark) taped at 5½ turns from cold end for 52mc.

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B&D Proportional

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L2—12 turns No. 16 wire airwound, with one wire diameter spacing, ½" inside diameter for 27mc.
L2—8 turns No. 16 wire airwound with one wire diameter spacing, ½" inside diameter for 52mc.
L3—4 turns No. 16 wire airwound, ⅝" inside diameter; couple 1/16" from end of 12 (27mc).
L3—2 turns No. 16 wire airwound, ⅝" inside diameter; couple 1/16" from end of L2 (52mc).
CRYSTAL SOCKET: National CS-7.
CRYSTAL: ½ of operating frequency, (Ace 20D17, 20D18 or 20D19 for 27mc), (International Crystal Co., Type FA9 for 52mc).
ANTENNA: Center loaded for 27mc (Ace 37A67-CLA) or per text; 58 inch for 52mc (Ace 37A7-TCU54).
Antenna Connectors: Amphenol microphone connectors 75-MC1F plug and 75-PC1M receptacle (furnished with Ace antenna).
S1—Normally open, momentary SPST pushbutton switch
S2, S3—Electrosnap E4-103 SPDT switch (Newark).
S4—DPST toggle switch.
S5—SPST toggle switch.
J1, J2—Open circuit phone jack.
Wiring harness connectors as preferred.
Tube shields (see text).
Misc. hardware as required.
Case: 3" x 8" x 9⅝" (Ace 21A16 #7).
Pro-Trol Stick assembly (Ace).
Handle: Cambion 1292-1 (Newark 40F2189 $0.88—not listed in catalogue).
Burgess 4156 22½V battery or equivalent.
4 4AH or greater NICAD batteries.
Power convertor (Ace TC3.6 Kit, No. 26A5) or equivalent.