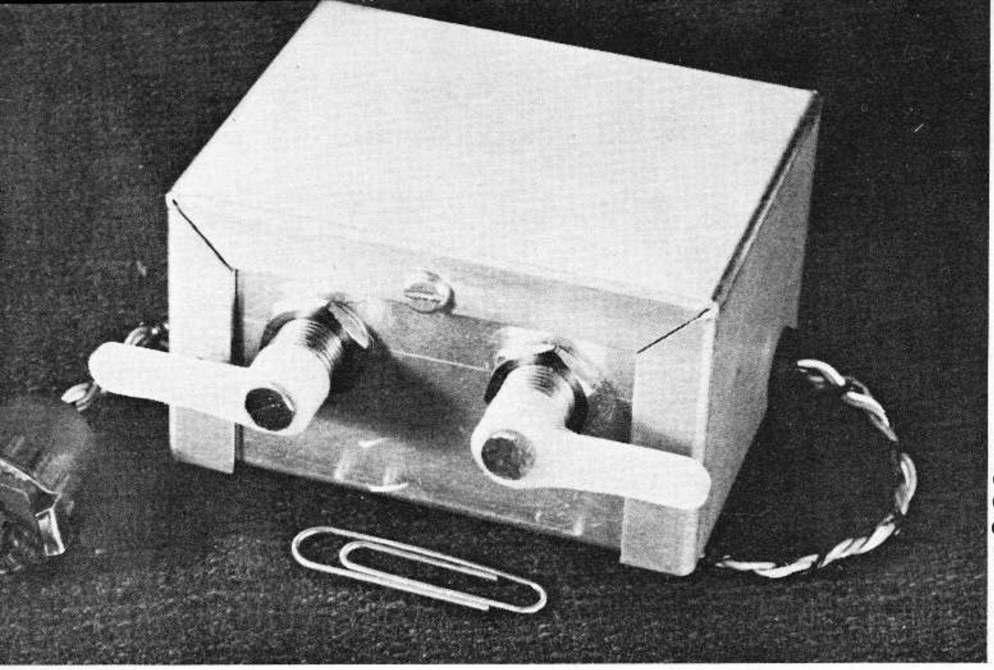
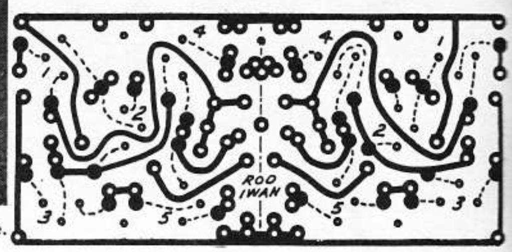


Complete dual servo ready for installation—the paper clip is used to show comparative size.

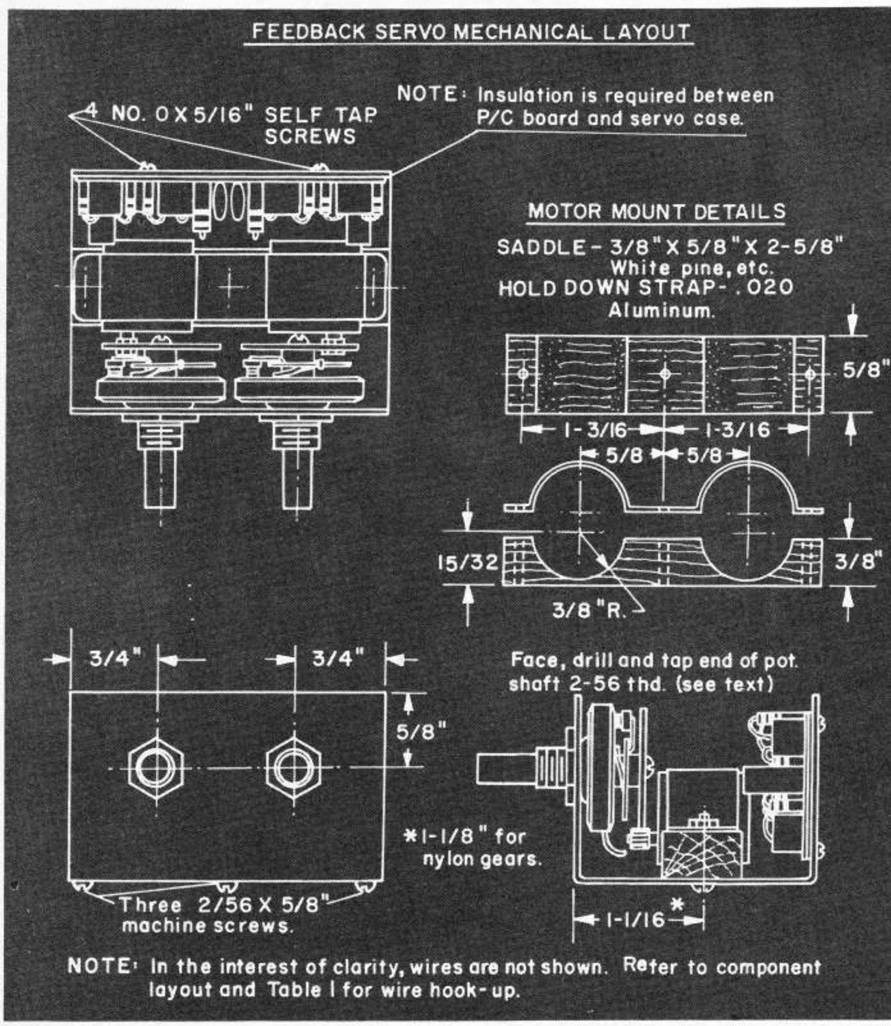
...B & D

by DON DICKERSON & NORM BEELER

Part Three B&D Feedback Servo



► The feedback servo circuitry used in the Pulsatone system is not original, but closely resembles several other circuits which have proved to be very reliable. The servos were designed to operate with a D.C. signal voltage of ± .5 volts, and may be used with other systems meeting this requirement. Separate reference batteries were not found necessary with the Pulsatone systems built to date, and are not shown. If a separate reference source is desirable or necessary for some other application, it may be easily incorporated by connecting the feedback pot power leads to the reference source instead of to the servo batteries. The center tap of the reference source must be connected to the center tap (plus 2.4 volts) of the servo batteries, of course.

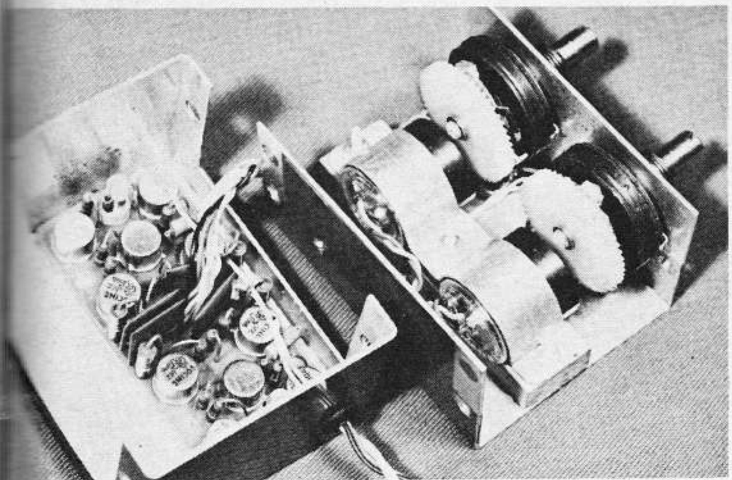


As seen from drawings and pictures, a single case houses both servos of the Pulsatone system. The completed weight is 7 oz., slightly on the heavy side (3½ oz/servo) but compensated for by the ruggedness of the unit. If desired, the unit may be split down the middle to make single servos (the printed circuit board design allows for this also). The construction of the dual servo is very easy to duplicate, with no critical dimensions or special machining required with the exception of drilling and tapping the potentiometer shaft. This operation is best performed on a lathe (we didn't have one either). One bright spot here however, Ace Radio Control will have available by publication date of this series of articles the potentiometer—gear set ready to go, as well as the required printed circuit boards. The total cost of parts to construct the two servos will be in the neighborhood of $40.

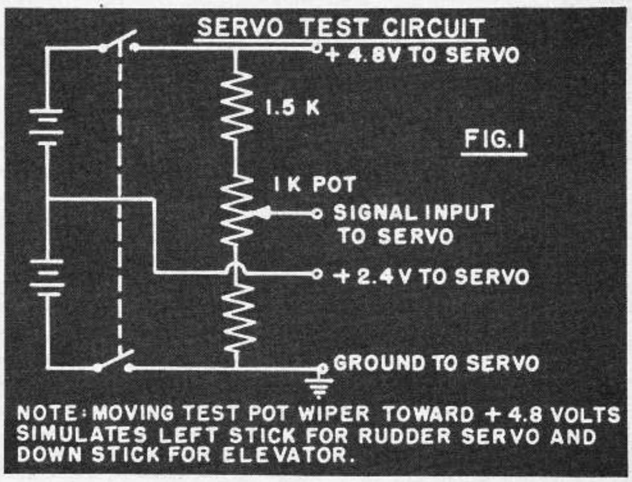
Construction comments will be divided into four sections to facilitate presentation in an orderly manner. The mechanical construction will be covered first, followed by printed circuit board construction, servo assembly, then servo checkout and trouble-shooting.

As stated before, the mechanical layout is very easy to duplicate and no detailed assembly instructions should be necessary. A few important points are mentioned, however. First, for those with access to a lathe, the pot modifications and gear attachment should be described. The pot cover should be removed and the shaft clamped in a collet or 3-jaw universal chuck in the metal lathe. The upset holding the metal plate and wiper assembly to the shaft is then faced flush with the surface of the metal

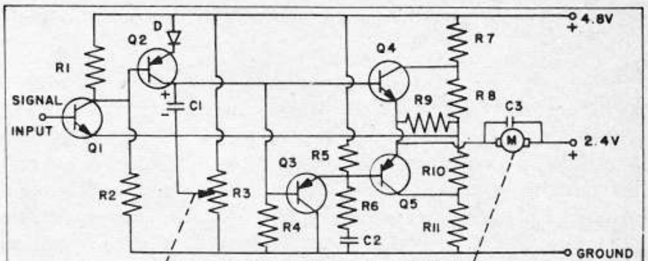
PROPORTIONAL SYSTEM



A look inside of servo—motors are Micro-Mo TO-3's, Pots are AB type "J"—case is the smallest size Bud "Mini-Boy," P/C in top of case.



THIRD AND FINAL PART — 1962'S TOP INTERMEDIATE SYSTEM—DETAILED INSTRUCTIONS FOR FEEDBACK SERVO THAT CAN BE USED WITH ANY OF THE PULSE SYSTEM.



NOTE: Schematic is shown for one servo only. Component numbering is same for both amplifiers. Transistor cases are internally connected to the base. Wherever necessary, snip off transistor index tabs to prevent shorting to component leads.

FEEDBACK SERVO SCHEMATIC

TABLE I - DIRECTION OF SERVO ROTATION

SERVO	RUDDER (RIGHT STICK)		ELEVATOR (DOWN STICK)	
DESIRED DIRECTION OF ROTATION	COUNTER C'WISE	CLOCK-WISE	CLOCK-WISE	COUNTER C'WISE
POT TERMINAL 1	4.8 V	GROUND	4.8 V	GROUND
2	Z	Z	Z'	Z'
3	GROUND	4.8 V	GROUND	4.8 V
MOTOR LEAD 1	X	Y	X'	Y'
2	Y	X	Y'	X'

NOTES: DIRECTION OF SERVO ROTATION IS DEFINED AS VIEWED FROM THE SHAFT END OF POTENTIOMETER.

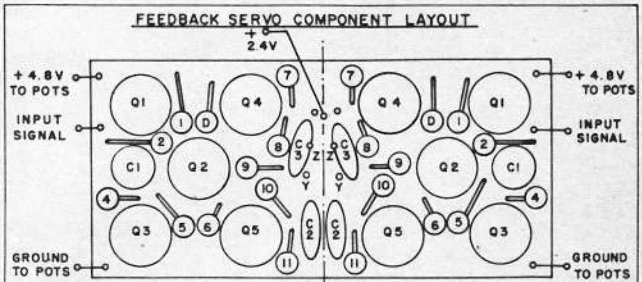
LETTERS X,Y,Z REFER TO TERMINATION POINTS SIMILARILY IDENTIFIED ON THE PARTS LAYOUT.

TABLE ABOVE ASSUMES FAST RATE FOR UP ELEVATOR 30% TONE ON FOR RIGHT RUDDER, AS SET UP BY PULSER-MODULATOR.

NUMBERING OF POT TERMINALS AS VIEWED OPPOSITE THE SHAFT END.

NUMBERING OF MOTOR LEADS AS VIEWED OPPOSITE THE SHAFT END — POSITIVE VOLTAGE APPLIED TO LEAD 1 GIVES CLOCKWISE ROTATION OF THE OUTPUT SHAFT AS SEEN FROM THE SHAFT END.

FEEDBACK SERVO COMPONENT LAYOUT



NOTES: Letters X,Y,Z are wire termination points. Refer to Table I for coding.
Diodes are inserted with cathode lead toward the board

plate (the plate won't fall off). The shaft should then be drilled ⅜" deep with a #51 drill and threaded with a 2-56 tap to give at least ⅛" of usable threads. The metal lug projecting from the plate (used as a stop when the cover is on,) may be used as a key to match a 3/32" hole drilled in the Mighty Midget output gear 15/64" from the center. The hub of the Mighty Midget gear should be knocked out, leaving a ⅛" shaft hole. This hole should be bushed down to fit 2-56 screw with brass tubing to help center the gear. Before assembling the potentiometer and output gear, relieve the wiper pressure somewhat by bending back until the pot turns fairly easily. In some instances, a small drop of oil is necessary at the juncture of the shaft and threaded shank (front of the pot) to relieve binding. The output gear and pot may now be assembled, using 2-56 x ¼ or 2-56 x ⅜ screws (depending on amount of thread you have in the pot shaft), washer and a 1/16" spacer between the gear and wiper assembly plate to provide clearance.

The Mighty Midget pinion gear should be drilled out with a #47 drill, and soldered to the Micro-Mo output shaft. Before soldering the pinion to the shaft however, the Micro-Mo cover plate and output shaft should be *removed* (careful you don't lose a gear). This is very necessary, soldering without removal will most likely result in damage to the plastic rear bearings. The output shaft may be cut to length with a razor saw. While you have the cover plate off, it is a very good idea to solder the brass bushing for the Micro-Mo output shaft to the plate, as they have a tendency to come loose after 150-200 flights.

If you have drilled the servo box and finished the motor mount and hold down strap, assemble the pots and motors and check the action. The gear mesh or back-lash adjustment, very easily made due to the eccentric location of the Micro-Mo output shaft, should be carefully made to prevent binding or bearing wear or damage. A slight back-lash should be felt at all positions of the potentiometer gear. A slight trueing up of the output gear may be necessary (loosen gear mounting screw and shift gear slightly).

This brings us to the printed circuit board construction. No particular sequence is necessary, but if transistors and diodes (*Continued on page 68*)

of its potential performance using 30-50 percent nitro fuel.

Performance was also checked on a straight "FAI" mixture of 3-1 methanol and castor-oil. On this, the peak output recorded was .365 bhp at 16,000 rpm's, compared with nearly .39 for the Tee-Dee on the same fuel. This increased discrepancy can be attributed to the lower compresion ratio which, of course, does not favor a "cold" fuel.

The new glowhead, incidentally, survived the full tests without burnout or deterioration. This included sustained rpm of over 20,000 (7x4 Power-Prop).

To sum up, the Special perfects what was, in the Tee-Dee, an already outstanding engine.

Summary of Date

Type: Two-part, two-cycle with opposed exhaust ports and twin bypass flutes. Shaft type rotary-valve intake.

Weight: 4.4 oz.

Displacement: 0.1525 cu.in. or 2.499 c.c.

Bore: 0.591 in. Stroke: 0.556 in.

Stroke/Bore Ratio: 0.941 : 1

Specific Output (as tested): 2.95 bhp/cu.in.

Power/Weight Ratio (as tested): 1.64 bhp/lb.

Price: $14.98.

Manufacturer: L. M. Cox Manufacturing Co. Inc., 730 Poimsettia Street, Santa Ana, California.

B&D FEEDBACK SERVO

(*Continued from page 29*)

are soldered in last, they are less likely to be damaged from the heat of soldering other components. The construction techniques outlined in the previous articles of this series should be followed. In selecting the transistors (using the tester shown in the first article of this series), Q1, Q2 and Q3 should be the lowest leakage units and Q4 and Q5 should be the highest gain units. If selected in this manner, typical variation between transistors of the types specified will give a servo with satisfactory operating characteristics. Two components, the damping resistors R9, should not be permanently installed until the proper value is determined (this adjustment is described later). After completing the printed circuit board, a careful examination should be made, checking for wiring errors, solder cross overs, cold solder joints, etc. Cleaning the solder resin with lacquer thinner helps quite a bit. The board should be filed so that there are no sharp points and everything is relatively flat for mounting purposes.

You should now be ready to assemble the servo. The photographs show two locations for mounting the printed circuit board. The back mount is the most convenient because of the absence of wiring to the top cover. However, the pot and gear kit to be furnished by Ace will feature nylon gears whose added thickness will make the top mount mandatory. Either location is satisfactory, of course.

In wiring the potentiometer and motor leads, refer to table 1 and you should end with the desired direction of rotation the first try. The motors and motor mount should be removed and the pots wired in first. Allow sufficient lead length so that the printed circuit board (or the cover if the board is to be mounted there!) may be removed from the case without removing the motors or pots. Reinstall the motors and wire in the motor leads. Be sure that each set of motor leads and the corresponding pot center tap go to the same amplifier. Now the wires may be bundled and printed circuit board installed (it will be removed later for servo checkout and installing R9). We shouldn't have to mention the required sheet of insulation between the printed circuit board and the servo box, but maybe we'd better, just as a reminder.

A word or two might be appropriate at this point on lead wire bundling and routing in general. Probably the single most important item in the reliability of the complete system (or any system actually) is the degree to which lead wires are protected from vibration fatigue. On the P.C. board, the wires should all be routed to leave the board at a common spot (the middle of the board, lower edge, as installed) and tied or braided together from there. The wires should be glued to the P.C. board (top side) from the wire termination point to this common exit point with Ambroid or other suitable adhesive (it should be easily removable if the need arises). The motor lead terminations at the rear of the motor case should also be coated with cement (Ambroid won't harm the plastic, you're on your own with anything else). The pot leads, routed *under* the motor mount, should also be generously coated at the pot terminals. If you have a lot of faith you may do this before checking the servo. It would probably be wiser to wait until check-out is completed however.

A couple of other items, and we will be ready to check out the servo action. If you haven't done so already, remove the p.c. board and tack solder in nominal values for R9. The board need not be installed for the check out if proper precautions are made against shorting the printed circuits. Next, build up the test circuit as shown by the schematic (figure 1). Both servo inputs may be hooked to the same test signal point. If you are too impatient to make one final wiring and battery polarity check, go ahead and throw the switch. After the smoke clears, the servos should have rotated to a null position and stopped. Rotate the test pot. and see if the servo output shafts follow. If they do, you can skip the next few pointers for those who weren't so fortunate. If one or both of the servos refuse to budge, check to see if the servo pot wiper is positioned at the extreme end of pot. travel (one end of the molded element). If such is the case, an error has been made in wiring or interpretation of Table I (after all the trouble we went to in making that table!). Switching servo pot. leads 1 & 3 or the motor leads (not both) of the offending servo should put the feedback signal in proper phase. If the servo absolutely refuses to work, a careful examination will most likely reveal a wiring error, as the circuit is sure fire if built correctly and no parts are defective.

Assuming you have a working servo, the only item left is to adjust the damping resistor R9 for optimum operation. Increasing the value of this resistor decreases damping and vice-versa. The desired damping characteristics, in our opinion, is at least one position overshoot with a step change in input signal voltage. Critical damping (no overshoot) results in an undesirable deadband, especially with a load on the servo. The damping adjustment is best made with the servos hooked up to the receiver output because of slight differences in response characteristics of the rudder and elevator signals so if you have finished the receiver and transmitter, go ahead and hook up the servos.

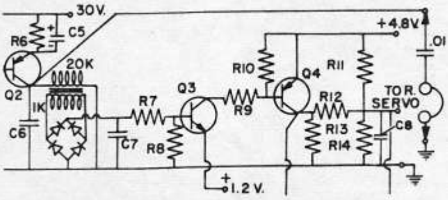
This leaves us with only a few loose ends to pick up to complete the feedback servos. First, the output arms seen on the photographs are Top Flite nylon bellcranks with one arm cut off. They were just pressed on after putting a slight bevel on the pot. shaft to prevent cutting the nylon.

Friction is enough to hold the arm in position for all but the most severe forces. A slot cut in the end of the pot. shaft would facilitate adjustment. If this idea scares you, the arm could be keyed with a pin or screw through the pot. shaft. In any event, do not use any type of metalic output arm, or you may end up with a noise problem. Second, in mounting the servo, use should be made of sponge rubber in order to reduce wear and tear due to vibration. The procedure used on the servos shown might be noted from the complete installation pictures in the previous articles; that of placing the servo in a box tightly packed with sponge, and a strap across the top to hold it in place. Care should be taken that fore and aft motion is restrained, however control surface neutral should not shift due to servo movement.

A few comments on the motor control servo should just about complete the servo system. The motor control servo amplifier, located in the receiver, was designed to take the stalled drain of a Mighty Midget. Use of a motor with a drain higher than this will undoubtedly result in transistor damage. Mighty Midget based servos have been presented in endless variety, and most any would be applicable to this system. Since the amplifier can withstand stalled drain, no limit switches are required, just mechanical stops at the travel extremes. The servo transit time should be somewhere between one-half and one second, depending on your engine acceleration characteristics and how nimble-fingered you are. A double geared Mighty Midget comes out about right. The almost standard Mighty Midget practices (strengthening lugs, bushing the armature shaft, tying in the brushes, etc.,) should be followed. An article by Jim Shows in the July/Aug. '62 issue of Grid Leaks gives some very good data on modifying the M/M. One last thought, any of the new low drain multi servos such as the Annco would be very appropriate, providing stalled resistance is not less than 5 ohms. The limit switches could be incorporated very easily into the collector leads of Q13 and Q14 (receiver schematic).

If "Ye Olde Editor" isn't pulling his hair about now over the word count, maybe we can squeeze in a few words on airplane installation, control surface areas and deflections, and proportional flying in general. Most important, control surfaces *must* move *very* freely and without binding or excessive play. Quite a few of you reed fliers have been getting away with murder in this respect, due to the forgiving nature of reed type servos. Feedback proportional servos however, will not perform satisfactorily with hard to move surfaces, the end result being poor neutral returns and a rough and very hard to control airplane. Areas particularly troublesome are steerable nosewheel linkages and coupled aileron-rudder schemes. An awareness of the problem and a little diligent effort in this direction should prevent any difficulty. Also, the current reed philosophy of just enough control surface area and deflection to give the minimum acceptable response should be followed. We've often seen practiced and heard words to the effect that "since you have proportional and can use just as little or as much stick as required, you can use large enough surface areas and deflections to cover any and all contingencies." This isn't true, and shows up as flight roughness. After all,

This completes this series on the Pulsatone system. We hope you will enjoy the success and reliability the authors have had with this system. We feel it offers a state-of-the-art advance to Class II control systems, under the old or the new proposed rules, as well as offering an economical entry into the proportional feedback type of control system. As a peek into the future, there is presently operating very successfully in an advanced breadboard fashion, a third proportional channel utilizing the tone frequency. This would require no modifications to the receiver and only slight changes to existing transmitters. The required circuitry would be housed in the additional servo. The successful application of this additional channel would make the Pulsatone system fully competitive in Class III.



Condenser C-8 is finally located correctly in B&D receiver — ignore correction in part two.

R1 2.2k R2 39k
R3 1.5k Ohmite type CU1521 potentiometer (Allied)
R4 1.5k R5 1k R6 47 ohm
R7 2.7 ohm (½ watt) R8 15k R9 1.2-3.9k
R10 15k R11 2.7 ohm (½ watt)
All fixed resistors, carbon, ¼ watt except where specified otherwise. Ohmite, (Allied)
C1 1 mfd IEI printed circuit type (Ace)
C2, C3 .047 mfd Sprague type HY-310 (Allied)
D 1N34A, IN66A, or other general purpose diode.
Q1, Q4 2N1302 or 2N1304 NPN transistor, Texas Instrument (Allied)
Q2, Q3, Q5 2N1303 or 2N1305 PNP transistor, Texas Instrument (Allied)
1—Servo box—Bud Minibox CU-3000A 1⅝" x 2⅛" x 2¾" (Allied)
2—Servo motors—Micro-Mo type TO-3, 59:1 gear ratio, low resistance winding*
2—Gear set—Mighty Midget gear and pinion or equivalent (Ace)
1—Printed circuit board—(Ace)
2—Nylon bellcrank—(Top Flite Models)
4—0 x 5/16 self-tap screws
3—2-56 x ⅝" machine screws with nuts
1—⅜" x ⅝" x 2⅝" motor mount (white pine, etc.)
1—.020" aluminum hold down strap
1—2⅝" x 1¼" x 1/64" insulation (phenolic)
1—5 pin plug and socket (any suitable type)
Hookup wire—(Bonner or equivalent)
*Micro-Mo motors may be obtained from either of the following at $9.75 each:
Tinker Town, 9658 Clayton Road, St. Louis 24, Mo.
Micro-Mo Electronics, Box 3952, Cleveland 20, Ohio.