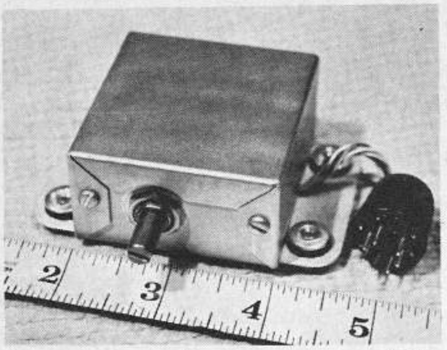
B&D DISCRIMINATOR

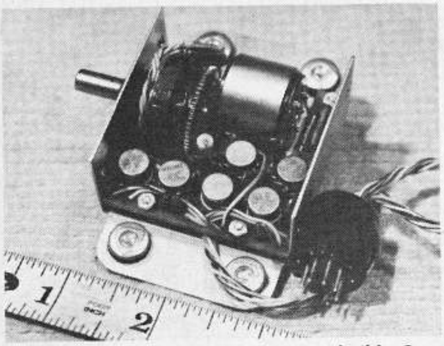
RECEIVER/SERVO MODIFICATIONS

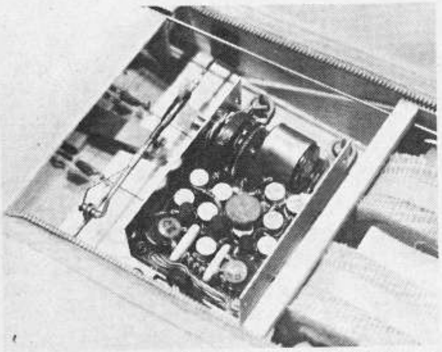
FINAL INSTALLMENT OF OUR EXTREMELY POPULAR TRIPLE PROPORTIONAL OUTFIT FOR MULTI RADIO-CONTROL. THIS INSTALLMENT INCLUDES ALL DATA TO UPDATE AND MODIFY RECEIVER AND SERVOS AS SHOWN IN 3,4,5/63 ISSUES.

PART TWO

By DON DICKERSON and NORM BEELER


Improved servo packaged one to a box, featuring temperature compensated, burn-out proof circuitry. Usable with feedback prop. systems.

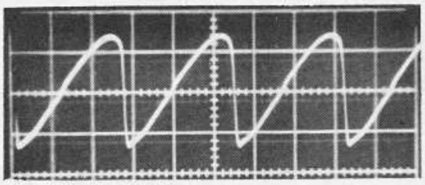

Design is simple, compact, easy to build. Case is cut down "mini-box." "AB" pots used again. Loose-leaf binders used for mounting hardware.

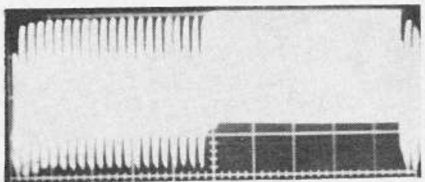

Prototype servo/discriminator installation in "Hustler." This early servo slightly different from drawings. Note aileron/nose wheel linkage.

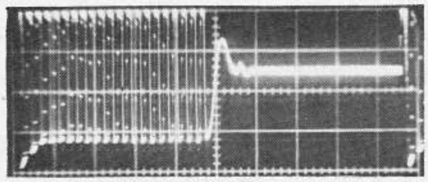
► This servo/discriminator provides a third simultaneous proportional control function for the B & D system making it fully competitive in Class III. The unit operates via variation of the modulating tone frequency and is normally used for ailerons. An individually packaged servo utilizing the improved servo circuit developed for the S/D is also described. This servo may be used to replace the earlier B & D dual servo or it may be used as an inexpensive but quality replacement for other servos. The S/D and single servo weigh 5½ oz. and 4 oz. and retail cost of parts is approx. $31 and $23 respectively.

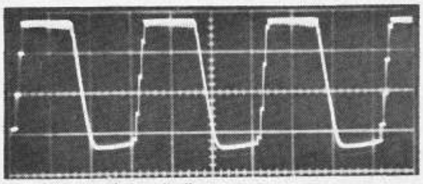
The discriminator circuit general configuration is not original with us. It is patterned after (*continued on next page*)

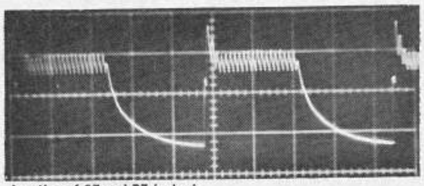
WAVEFORMS FOR THE B & D RECEIVER—REFER TO SCHEMATIC IN MARCH, 1963 MAN

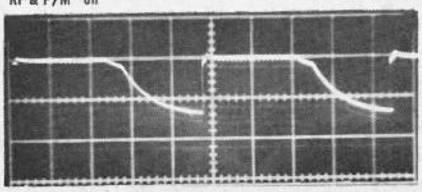

Base of Q1—RF only "on"
Vertical: .5V/div
Horiz: 5 micro-secs/div.
Quench frequency waveform

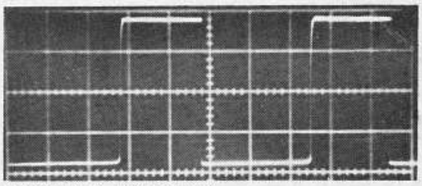

Base of Q1—RF & P/M "on"
Vertical: .5V/div
Horiz: One pulse cycle shown
(Emitter of Q1 is similar)

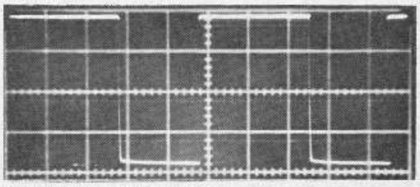

Collector of Q2—RF & P/M "on"
Vertical: 15V/div
Horiz: One pulse cycle shown

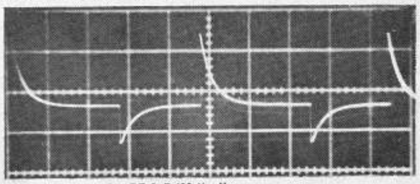

Col. of Q2—Steady tone "on"
Vertical: 15V/div
Horiz: .2 milli-sec/div
Three tone cycles shown

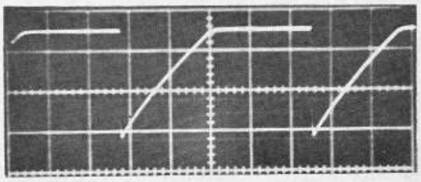

Junction of C7 and R7 (output of full wave bridge rectifier)
Vertical: 2V/div
Horiz: Two pulse cycles shown
RF & P/M "on"

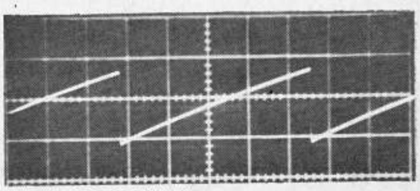

Base of Q3—RF & P/M "on"
Vertical: 1V/div
Horiz: Two pulse cycles shown

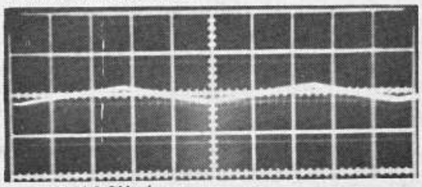

Collector of Q3—RF & P/M "on"
Vertical: 1V/div
Horiz: Two pulse cycles shown
(Collector of Q6 is similar)


Collector of Q4—RF & P/M "on"
Vertical: 1V/div
Horiz: Two pulse cycles shown
(Collector of Q7 is similar)


Base of Q5 & Q8—RF & P/M "on"
Vertical: 2V/div
Horiz: Two pulse cycles shown


Base of Q6—RF & P/M "on"
Vertical: .5V/div
Horiz: Two pulse cycles shown


Base of Q9—RF & P/M "on"
Vertical: .5V/div
Horiz: Two pulse cycles shown


Junct. of R21 & C11, elev. filter output (rudder filter output is similar)
Vertical: .5V/div
Horiz: Two pulse cycles shown

B & D . . . continued

the circuit used in a well known "multiplex" quad-proportional system but with circuit values and voltages changed to suit our requirements. Our version is not perfect, but it performs amazingly well considering it must work under adverse conditions of varying pulse rates and widths, both of which are fixed parameters in the multiplex system from which this circuit was derived.

Here's how it works: Q1 is a high input impedance clipper stage directly coupled by R1 to the collector of Q2 (audio output) in the receiver. The output of Q1 feeds the stagger tuned LC circuits, L1-C1 and L2-C2 through resistors R4 and R5. (Refer to fig. 1 which shows the frequency response of each tuned LC circuit in terms of peak A.C. voltage at the base of Q2 and Q3 as referenced to 2.4 volts.) The A.C. voltage across each parallel tuned L-C circuit depends on the tone frequency and is maximum at the resonance frequencies, f1 and f2 in fig. 1.

At f0, (neutral aileron), the peak voltages at the bases of Q2 and Q3 are equal, opposite in polarity, and about 50 to 60 percent of the amplitude attainable at f1 and f2. As frequency is varied from f0, the peak A.C. volts at Q2 and Q3 will remain opposite in polarity but different in amplitude, with the difference dependent on applied frequency.

The high input impedance emitter follower stages Q2 and Q3 function as peak detectors which charge memory capacitors C3 and C4 to a D.C. level approx. equal to the peak A.C. volts being applied to their bases. The D.C. voltages are amplified by a factor of approx. three by the D.C. amplifiers Q4 and Q5.

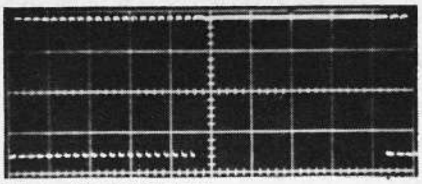
Resistors R10, 11, 12, and 13 and capacitor C5 form a summing network whose output is the algebraic sum of the D.C. voltages at the collectors of Q4 and Q5.

Whenever the tone frequency is varied, capacitors C3 and C4 will assume new D.C. voltage levels corresponding to the new value of peak A.C. volts applied to the bases of Q2 and Q3 and the summing network output will vary accordingly Thus the output of the discriminator is a D.C. voltage whose amplitude and polarity is dependent on the transmitter modulation frequency.

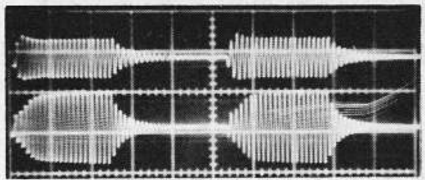
In the absence of an input as during low throttle command, the discriminator output will automatically return to the 2.4 volts neutral value. Happily, during high throttle command (steady tone) aileron control is retained.

In the interim between tone bursts, C3 and C4 remain at essentially the voltage level established by the last couple of tone cycles. In practice, however, there is some discharge through R6, R7, and the D.C. amplifiers Q4 and

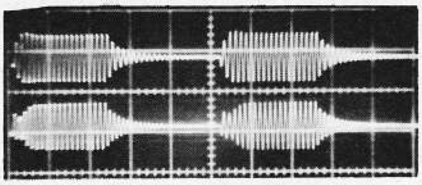
WAVEFORMS FOR THE B & D DISCRIMINATOR/SERVO



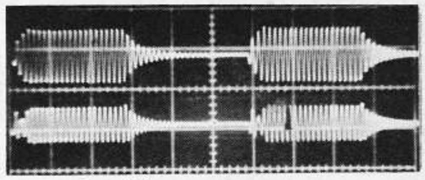
Collector of QI—RF & P/M "on"
Vertical: 2V/div
Horiz: One pulse cycle shown



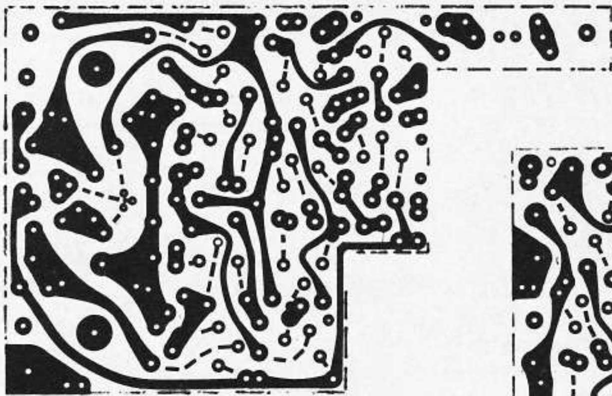
Top trace—Base of Q3
Bot trace—Base of Q2
Vertical: 1V/div
Horiz: Two pulse cycles shown (right aileron)



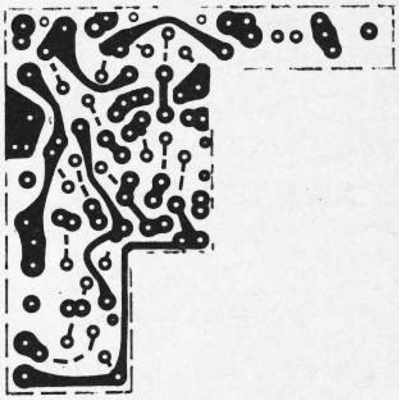
Top trace—Base of Q3
Bot trace—Base of Q2
Vertical: 1V/div
Horiz: Two pulse cycles shown
(Neutral aileron)



Top Trace—Base of Q3
Bot Trace—Base of Q2
Vertical: 1V/div
Horiz: Two pulse cycles shown
(left aileron)



Above—Conductor side of servo/discriminator printed circuit board. (Actual size)



Right—Conductor side of single servo printed circuit board. (Actual size)

Q5. As a result, somewhat less control deflection is available when the tone "on" duty cycle is short. This has little significance in practical application since there is no interaction at or near aileron neutral.

Also, some temperature drift can be expected due to slight changes in resonant frequencies of the tuned circuits with temperature and unbalanced characteristics of the complementary transistor pairs Q2-Q3 and Q4-Q5. Although drift here is greater than in any other part of the B & D system, it is tolerable and within aileron trim range over normal R.C. flying temperature ranges. Unfortunately, drift is almost impossible to eliminate in D.C. circuits such as this.

The servo circuit is essentially a refinement of the circuit presented in the original B & D series. It features improved response and damping, burn-out protection, greater torque, better resolution, and vastly improved temperature stability.

R27 and R28 determine the amount of servo deflection with a given input voltage. Increasing their value increases deflection and vice versa. The emitter follower stage, Q6 and R14, is solely for temperature compensation of the next stage, Q7. Temperature effects of Q6 and Q7 are opposite in direction and approx. equal; therefore, they cancel. (This very effective method of temperature compensation is worth adding to your present B & D servos. The photo shows how it is done. Be sure to insulate the piggy-back transistor cases from one another and adjacent component leads. While you are at it, remove the diodes and replace them with jumper wires. Also, remove both R2's. And don't replace them with anything.)

The higher supply voltages used on the servo information electronics are advantageous to servo performance, but were primarily dictated by the requirements of the discriminator. If the reader wishes to use the single servo with some other system that hasn't the higher voltages, it is permissible to connect the 6.0V. and —1.2V. leads to 4.8 and zero V. respectively. To retain the same damping characteristics and servo sensitivity, it will be necessary to increase the value of the damping resistor R15 and to omit R27 and R28.

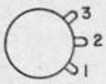
Mechanically, (*Continued on page* 56)

TABLE I – DIRECTION OF SERVO ROTATION					
DESIRED DIRECTION OF ROTATION AS VIEWED FROM SHAFT END OF POTENTIOMETER, R29	CONNECTIONS				
	POT TERMINALS			MOTOR LEADS	
	1	2	3	1	2
CLOCKWISE - WITH NEGATIVE INPUT TO SERVO (REFERENCED TO PLUS 2.4 VOLTS)	D	H	B	Y	X
COUNTER CW - WITH NEGATIVE INPUT TO SERVO (REFERENCED TO PLUS 2.4 VOLTS)	B	H	D	X	Y

NOTES:

1.) THE B & D TRANSMITTER, RECEIVER, AND DISCRIMINATOR PROVIDE NEGATIVE INPUTS TO SERVOS (REFERENCED TO PLUS 2.4 VOLTS) WITH RIGHT RUDDER, RIGHT AILERON, AND UP ELEVATOR WHICH CORRESPOND TO 30% TONE ON, HIGH TONE, AND FAST PULSE RATE RESPECTIVELY.

2.) THE LETTERS IN THE ROTATION TABLE REFER TO POINTS SIMILARILY IDENTIFIED ON THE COMPONENTS LAYOUT.

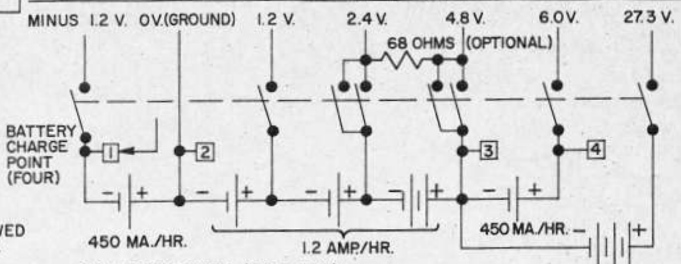


NUMBERING OF POT TERMINALS AS VIEWED OPPOSITE FROM THE SHAFT END.

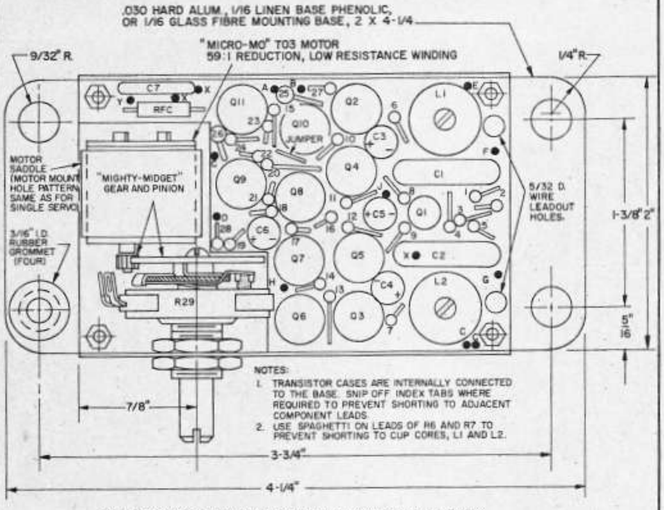
NUMBERING OF MOTOR LEADS AS VIEWED OPPOSITE THE SHAFT END - POSITIVE VOLTAGE APPLIED TO LEAD 1 GIVES CLOCKWISE ROTATION OF THE OUTPUT SHAFT AS VIEWED FROM THE SHAFT END.

FOR CLARITY, POWER AND SIGNAL WIRES ARE NOT SHOWN ON THE COMPONENT LAYOUTS. THE SMALL DOTS ON THE COMPONENT LAYOUTS INDICATE WIRE TERMINATIONS, AND THE LETTERS INDICATE THE FUNCTION OF THE WIRE BY THE FOLLOWING CODE:

A - PLUS 4.8 VOLTS
B - TO R29
C - ZERO VOLTS
D - TO R29
E - PLUS 6.0 VOLTS
F - INPUT
G - MINUS 1.2 VOLTS
H - TO R29 WIPER
J - DISCRIMINATOR OUTPUT MONITOR (OPTIONAL)
X - PLUS 2.4 VOLTS AND TO MOTOR
Y - TO MOTOR

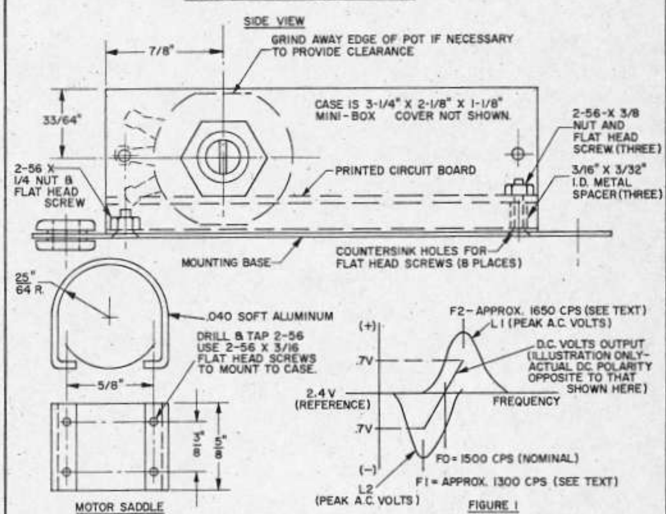


POWER SCHEMATIC (SEE TEXT)

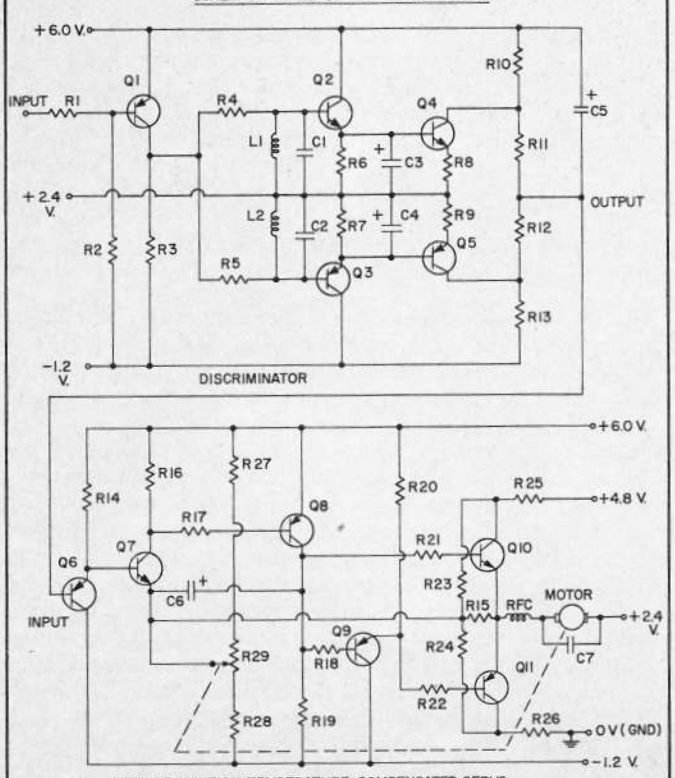


B & D SERVO/DISCRIMINATOR-COMPONENT LAYOUT AND ASSEMBLY

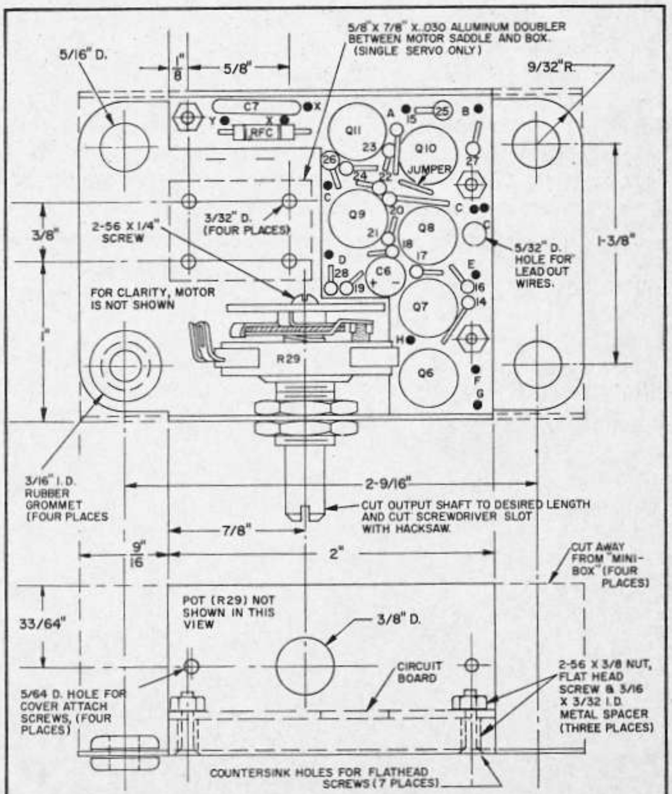
DETAILS - B & D SERVO/DISCRIMINATOR



SCHEMATIC - B & D SERVO/DISCRIMINATOR



HIGH RESOLUTION TEMPERATURE COMPENSATED SERVO



B & D SINGLE SERVO - COMPONENT MOUNTING AND ASSEMBLY

B & D Servo/Discriminator

(*Continued from page* 28)

we've adhered to earlier B & D servo concepts for simplicity. Unfortunately, the nylon gear supplied by Ace with their gear and premodified pot sets cannot be used because of case depth limitations. We used Mighty Midget metal spur and pinion gears although the Mighty Midget nylon spur gear should also work very well.

The procedure for modifying the pots and mounting the Mighty Midget gears was completely described in the May, 1963 MAN and we have nothing to add except to recommend that the pinion gear be fastened to the motor output shaft with epoxy cement rather than solder and that the pot shaft shoulder be lubricated with automotive distributor cam grease where it rubs against the pot mounting bushing. And don't forget to loosen up the pot wiper spring tension a bit to reduce the drag. We also stick the carbon wiper block firmly to its seat with a tiny bit of silver conducting paint to prevent side play, but this isn't mandatory.

The temperature stability and general performance of both the discriminator and servo will be enhanced if certain components are selected and matched as follows:

1. Each transistor in the complementary pairs Q2-Q3, Q4-Q5, Q6-Q7 should closely match its partner in gain and leakage. Low to moderate gain (30-75) and low leakage units are best for these positions. Q8 and Q9 are not especially critical, but extremely high gain high leakage transistors should be avoided. Very high gain units (100-300) are best for Q10 and Q11 and high leakage is not detrimental. Q1 is not critical and any normal 2N217 can be used. (The transistor checker described in the March 1963 MAN can be used for transistor selection).
2. The complementary resistor pairs R6-R7, R8-R9, R10-R13, and R11-R12, and the capacitors C3-C4 are not especially critical as to actual value, but the more closely each pair is matched, the better the servo.

To test the completed single servo, power it up and connect the input to the wiper of a 1K test pot connected in series between two 1.5K resistors across 4.8 volts. When the test pot shaft is rotated, the servo pot should follow. If the servo pot goes to one extreme and remains there, you've misinterpreted Table I so reverse *either* the motor leads or the feedback pot leads. If the servo is overdamped (sluggish and too much deadband) increase damping resistor R15; if it is underdamped (touchy and "jiggles" too long before settling into a new null position) decrease R15. When adjusted properly, this servo will have practically no overshoot. It seems to just buzz along and come to a sudden stop.

The bobbins for L1 and L2 are initially wound about three-fourths full with No. 40 enameled wire. The winding direction doesn't matter, and the wire doesn't have to be wound in neat layers although neatness isn't objectionable! We use a hand drill clamped in a vise for a winder. When complete, the cores and bobbins can be temporarily assembled to the PC board. Leave the pigtails long and run them around the edge of the PC board and temporarily tack solder them in place.

The discriminator should be adjusted before the servo section is connected to the pot and motor. An oscilloscope, audio signal generation, and VTVM or VOM are required. Here's how:

1. Connect the S/D to power.
2. Connect an audio signal generator between the input and minus 1.2 volts. The audio-generator should be pre-set to square wave if available, sine wave if not, zero volts output, and 1500 c.p.s.
3. Connect the scope between the collector of Q1 and minus 1.2 volts. Increase the output of the audio generator until a 1500 c.p.s. square wave appears on the scope, and continue increasing the output until there is no further increase in amplitude of the square wave.
4. Connect the scope between the base of Q2 and plus 2.4 volts. Vary the input frequency to find f2 which will undoubtedly be well below 1500 c.p.s. Remove several turns of wire from L1, and repeat the procedure. Continue this process until L1-C1 resonates at about 1600 to 1650 c.p.s.
5. Connect the scope to the base of Q3 and repeat the procedure of step 4 for L2-C2 except this time aim for a resonant frequency, f1, which sets up the following condition: At the frequency (f0) where

son.

B & D

(*Continued from page* 57)

the amplitude across L1-C1 is 50 to 60 per cent of that at f2, the amplitude across L2-C2 shall be 50-60 per cent of that at f1. When this condition exists, f2 will fall somewhere in the vicinity of 1250 to 1350 c.p.s.

6. Connect the VTVM or VOM between the output of the discriminator and plus 2.4 volts. Varying the frequency between f1 and f2 should give an output voltage of plus and minus .7 to .8 VDC.

7. Permanently fasten down the cup cores, shorten the bobbin lead wires and carry them through the PC board and neatly solder. *After* the S/D is completely checked out, it is advisable to stick the fragile coil leads to the cup core and the PC board with coil dope or contact cement to prevent damage, and to ooze some back into the cup cores to prevent the bobbin from shifting about.

Thoughout the above procedure, keep these facts in mind:

1. The cores are conductive and mustn't short against any other component leads.
2. Cup cores vary in permeability and should not be intermixed during the adjustment procedure.
3. The cores must be pulled down snugly during each frequency check with the 1-72 x ½ screws, and the mating surfaces must be kept clean so that the two halves will make intimate contact.
4. The cup cores and fine wire windings are tedious to work with. Before you have them properly adjusted, you will probably wish you'd never heard of B & D. But remember, in the end, it will have been worth it!

To check out the servo section, simply hook up the pot and motor leads to obtain the desired direction of servo rotation per table 1, install the PC board in the case and fire up the S/D using the audio signal generator as a signal source.

To operate the S/D with the rest of the system, simply wire the airborne components per the power schematic and connect the input to the collector of Q2 in the receiver. It will, of course, be necessary to adjust R20 in the transmitter to obtain the proper neutral frequency, f0. Full left and right aileron stick travel should produce at least plus and minus .4 volts discriminator output. If it doesn't, increase the amount of frequency change by increasing C5 in the transmitter to .1 MFD and readjusting for neutral tone frequency.

There should be no interaction with either pulse width or pulse rate with the aileron servo at or near neutral. At S/D position appreciably away from neutral, variation of pulse width will cause some aileron deflection because of the decreased discriminator output with low percentages of tone "on" tone. In addition, right aileron (fast tone) may produce more control deflection than left. The non-linearity can be considerably reduced or eliminated at the aileron by employment of suitable non-linear linkage geometry.

Here are a few changes you can make to your receiver to enhance its temperature stability and make it better suited to the servo/discriminator.

1. Insert 22 ohm resistors between plus 4.8 volts and the emitters of Q4 and Q7. (See photo). It will be necessary to readjust R17 in the receiver and to increase the percentage of tone "on" time at the

transmitter to obtain proper neutral output from the rudder and elevator filters.
2. Change R11 and R14 to 8.2K and 6.8K respectively.

Since the original B & D series was published, we've received a tremendous amount of correspondence from the field, and by now we are well acquainted with the problems encountered by some builders. The most frequent complaints are discussed below.

Lack of Range. This problem is attributable to one or a combination of insensitive superegenerative detector, low gain audio stage (Q2) in the receiver or low output transmitter.

Here is a more precise procedure for setting up the detector than the one described in the receiver article.

1. Use a 1mmf mica or NPO ceramic capacitor at C1 for 52 mc., and 2 or 2.2 mmf for 27 mc. (Despite what the author once said about it in Grid Leaks). Tack in a 39 mmf mica or NPO ceramic with leads cut to ¾" or less at C2.
3. Check the filament voltage to make sure it is between 1.35 to 1.5 volts. If less than 1.35 volts, reduce R31 from 27 ohms to 22 ohms. Use a fresh 22½ volt "B" battery.
4. Connect about 30 inches of antenna.
5. Turn on receiver and listen for the hiss at the collector of Q2 with headphones connected in series with an .01 capacitor as described in the receiver article, or look for it with an oscilloscope. If none is heard, increase C2 until it occurs.
6. Set an antennaless transmitter about three feet from the receiver, turn on RF and the P/M and tune the receiver.
7. Connect an oscilloscope between the emitter of Q1 and ground. The waveform should be as shown in the waveform photo. Tune for the maximum peak to peak voltage of the superimposed audio tone, and note the amplitude.
8. Reduce C2 a few mmf, and again tune for maximum amplitude, which will likely be greater than before.
9. Repeat step 8 until no further increase in output is obtained. Permanently install the largest value for C2 that gives maximum output.
10. Install the receiver in the case and perform the low voltage check described in the receiver article. If the receiver will super-regenerate with antenna connected down to 20 volts or less, you are in business. If it quits above 20 volts, reduce R2 to about 22K and try again. Sometimes it may be necessary to increase C2 by just a few mmf.

We've noticed that with an optimum adjusted superregenerative detector, the hiss volume is very slightly less with a full antenna connected than with no antenna, and that grasping the antenna will have some effect on hiss volume. If the hiss volume seems totally unaffected by antenna length and by grasping the antenna, and if the optimum C2 is small (18 to 27mmf) it may be indicative that C1 is too small. This is more likely on 52 mc. where the tolerance of C1 usually is plus or minus 50 percent. If larger than 39mmf. is required at C2 for superregeneration, and the superregenerative hiss volume is appreciably louder with all the antenna removed than with it connected, it is very likely that C1 is out of tolerance on the high side. (The same effect is sometimes observed when C2 is too small and with C1 normal, but here multiple tuning spots are often observed).

If your superregenerative detector output is as shown in the waveform (base and emitter of Q1) and the waveform at collector of Q2 isn't a clipped sine wave as shown, then Q2 probably hasn't been selected for a gain of 140 or better per instructions or C4 and/or C5 may be defective or installed with polarity reversed. And, less likely, C6 may not be of optimum value. We've found that a 5 to 10 MFD 30 volt electrolytic capacitor connected between B plus and ground will often give considerable improvement and we recommend that one be installed. We use a 4.7 MFD tantalum (C14) installed as shown in the photo.

If your receiver was properly set up and you still don't have adequate range, then your transmitter probably is too low in output, and the cure is obvious! We cannot recommend or condemn specific transmitter designs but doubt that anything with less than about 300 mw of *honest* RF output would be adequate. This probably eliminates most transistorized transmitters and perhaps some of the weaker tube types. For example, most local Kraft conversions have not been very successful although some correspondents report success with them and with some other transmitters known to have very low output. We obtain in excess of 1/3 mile ground range with our 27mc. handheld transmitter and about 1/5 mile with the 52 mc. version. With no antenna on the transmitter and with the front cover in place, we get about six feet and thirty feet for the 27 mc. and 52 mc. respectively.

Servos become erratic and operate spontaneously while the engine is running but the system works O.K. at other times. This condition can range from an occasional spontaneous twitch of the elevator in flight to the other extreme where the servos oscillate wildly and spontaneously anytime the engine is running.

A rare and occasional "twitch" while the plane is several hundred feet out may be due to so called "dead spots" where RF field strength is weak, possibly due to pointing the antenna straight at the plane. Or, it may be caused by interference from other transmissions or noise. A marginal output transmitter can aggravate all the above conditions.

If the servos are erratic even when near the transmitter, there is undoubtedly a noise problem. Causes and cures are as follows:

1. *Static noise from vibrating metal to metal linkages, metal throttle servo gears, and metal objects rubbing against the servo and receiver cases.* All metal to metal linkages should be insulated at points of mutual contact: bonding isn't recommended because it is subject to breakage and makes the linkage into an even longer transmitting antenna. Nylon gears are preferable for throttle control servos and Top Flite nylon bell cranks with one arm cut off are still recommended for servo arms. (They are much easier to press in place if first reamed out with a ¼ in. drill. Another advantage —they can "slip" in a crack-up and save the servo).
2. *Electrical noise caused by vibration induced intermittent pressure contacts in the electrical installation.* Battery box contacts, switches and connectors are all potential and common trouble spots. We prefer to solder all battery connections, and to wrap the batteries in sponge to keep *internal* connections from becoming intermittent from fatigue. (Oh, how we learned that's the hard way!) Good firm connectors should be used and it is best that neither half be fastened to airplane structure. Switches are chronic offenders, but we've had good results with the inexpensive Ace slide switches with the knife contacts. Keep solder flux and any other foreign matter out of these switches.
3. *Electrical noise caused by microphonic 1AG4 tubes and vibrating relay contacts.*

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Some 1AG4 tubes have loose elements which under vibration can change spacing and modulate the plate current. To check for this condition, monitor the waveform at the collector of Q2 with a 'scope with the transmitter and P/M on, and at the same time keep an eye on the elevator servo.

If the tube is microphonic, lightly tapping it with the rubber end of a pencil will cause large noise spikes to appear between the tone bursts, and the elevator servo may respond. All tubes will exhibit some noise and judgement is required, but in general, ten volts peak to peak is about maximum permissible. Doubtful tubes should be replaced and the regen stage checked out again. Vibrating POD relay contacts can cause the throttle servo amplifier and throttle servo to intermittently conduct and possibly create electrical noise. Tightening the relay armature spring as tightly as possible commensurate with reliable pull in and padding the receiver lightly in soft sponge rubber will help.

One of the best ways to locate vibration induced noise sources is to monitor the collector of Q2 with a scope while the engine is running, and the transmitter and P/M are on. If noise spikes appear in the interim between tone bursts, lift out the major components, receiver, battery pack, etc., one by one to isolate them from vibration. The process of elimination should soon get results.

On some 52 mc. receivers, a voltage spike not caused by vibration but sufficient to be detrimental was observed at the collector of Q2 in the interval between tone bursts. The spike is caused by switching transients in the decoder circuits feeding through the 1AG4 tube filament, and can be eliminated by replacing R31 with a 10 micro-henry RFC of the type specified for RFC in the 52 mc. receiver and relocating R31 on the bottom of the PC board between the R.F.C. and 2.4 V. or by using a separate filament battery.

The servos become erratic and will not failsafe properly with the transmitter RF off. Unfortunately, this is a normal characteristic of some B & D receivers. It was not mentioned in the earlier series because the two original B & D receivers didn't exhibit this characteristic and we weren't aware of it. It is caused by the superregenerative "hiss" and/or throttle servo noise triggering the decoding circuits in the receiver. Unfortunately, the receiver doesn't employ narrow band pass filtering. It does employ a form of amplitude rejection which we obtain by reverse biasing Q3 by 1.2V. Approximately 20 volts peak to peak is required on the primary of the transformer to overcome this bias, but noise and "hiss" sometimes exceed this. The rejection level can be raised by decreasing R8 to 5.6K which may help. Otherwise, the transmitter will just have to be turned on before the receiver. We are not presently planning a re-design.

The servos smoothly and uniformly oscillate a few degrees about neutral during high and low throttle command. This is caused by Nicad batteries that have excessive internal resistance and cannot deliver peak current demands to the servo motors without excessive voltage drops at their terminals and/or by excessive resistance in the wiring between the batteries and the servos.

This problem will be eliminated and general operation enhanced if your airplane installation is as follows:

1. Use 1.2 amp/hr. Nicads for the 4.8 volt supply and 450 ma/hr. for the additional cells on each end.
2. Use two Ace 4PST slide switches mechanically linked to operate together, and wire two poles in parallel for the 2.4 and 4.8 volts.
3. Use No. 20 or 22 wire from batteries to switches.
4. Use the battery zero volts lug and the downstream switch lugs for "central distribution points" and run separate No. 22 power and ground leads to each servo and to the receiver.

In closing this series we wish to thank John Phelps for permission to publish basic features of his pulser circuit, and fellow McDonnell Club members Don Casper for photography and Al Signorino for help with drawings, and of course, our partner, Norman Beeler, who first proved the feasibility of the third proportional control and did the initial breadboard work on the discriminator. Unfortunately, distance prevented Norm from participating in preparation of this last series.

PARTS LIST

R1, R2, R5	100K	All fixed resistors, Ohmite, carbon, ¼ watt except where specified otherwise. (Newark)
R3, R14	4.7K	
R4	120K	
R6, R7	10K	
R8, R9	470 ohm	
R10, R13, R19, R20	1.5K	
R11, R12	8.2K	
R15	3.3K (some servos may require different value, see text)	
R16	2.2K	
R17, R18, R21, R22	47 ohm	
R23, R24	5.6K	
R25, R26	2.7 ohm, ½ watt	
R27, R28	390 ohm	Gears—Mighty Midget pinion and brass or nylon spur (Ace)
R29	1.5K linear pot; modified Ohmite CU1521 (or use Ace no 29A25 which is already modified)	
C1	.022 Mfd, 100V mylar, Mallory 1122 or Cornell-Dubilier WMF 1D22 (Newark, Allied)	
C2	.033 Mfd, 100V mylar, Mallory 1133 or Cornell-Dubilier WMF 1D33 (Newark, Allied)	
C3, C4, C5	14 Mfd, 15V plug in electrolytic, IEI (Ace)	
C6	1 Mfd, plug in electrolytic, IEI (Ace)	
C7	.01 Mfd disc ceramic	
Q1	2N217	
Q3, Q5, Q6, Q8, Q9, Q11,	2N1303 or 2N1305 Texas Instrument (Allied)	
Q2, Q4, Q7, Q10	2N1302 or 2N1304 " " "	
RFC	RCA 10 micro-henry (Ace)	
circuit boards	(Ace)	
Motor	Micro-Mo, TO3, 59;1 reduction, low resistance winding. (Ace)	
L1, L2	Ferroxcube 7F160-3E pot cores and 405F150 bobbins, #40 enameled magnet wire, 2 1-72 x ½ screws (Ace 36A2)	
Servo case	3¼ x 2⅛ x 1⅛ LMB Utilty box No. T-F772 or Bud mini-box CU-3017-A (LMB preferred) (Newark)	

Addresses:

Allied Radio, 100 N. Western Ave.,
Chicago, Illinois
Ace Radio Control, Box 301, Higginsville, Missouri

Newark Electronics, 223 W. Madison St.,
Chicago, Ill.
Ferroxcube Corp. of America,
Saugerties, New York.