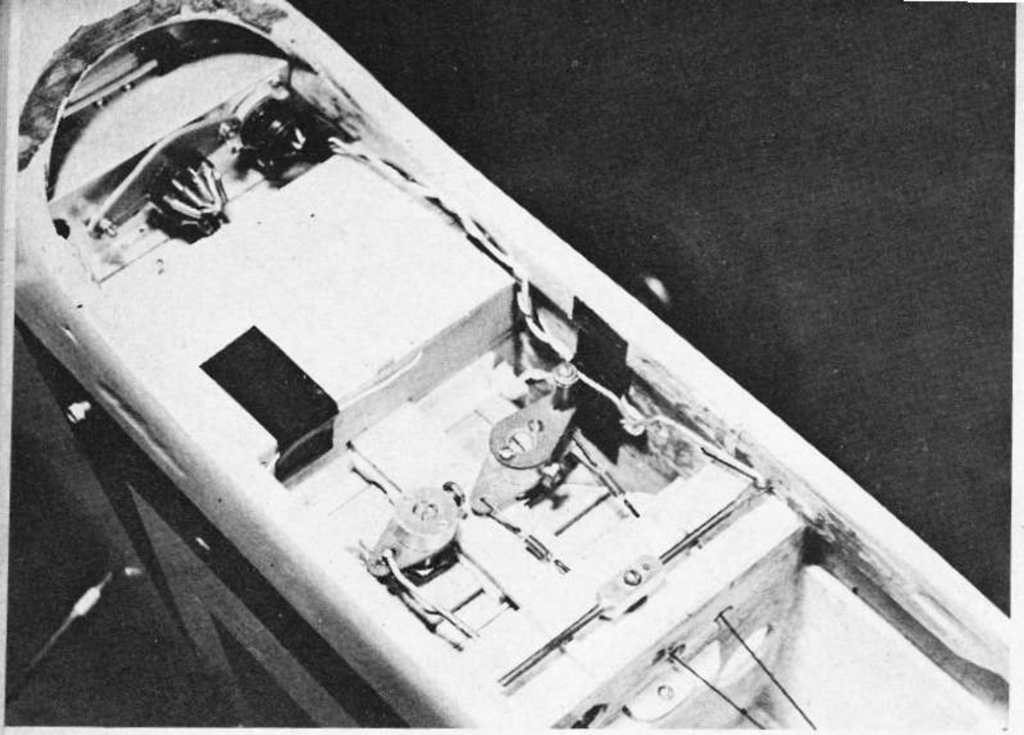


Inside of authors' "Yellowbird" receiver to the right and forward rudder servo and aileron bellcrank—nylon cords extending to the rear are used to actuate the rudder instead of pushrod.

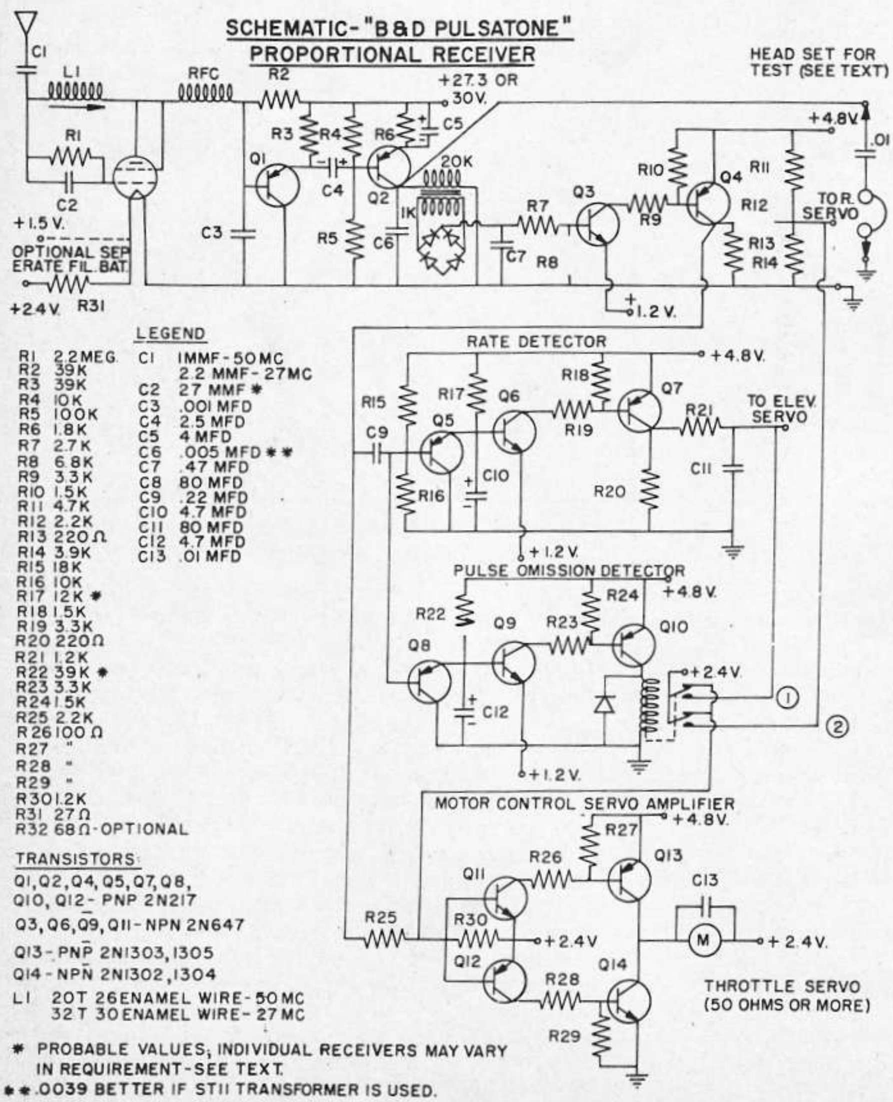
...B & D

Part One

PULSATONE RECEIVER

FIRST OF THREE PARTS OF 1962'S TOP INTERMEDIATE SYSTEM—DESIGNED FOR MAXIMUM PERFORMANCE, IT WAS WELL AHEAD OF THE MANY OTHER INTERMEDIATE SYSTEMS INCLUDING 10-CHANNEL REED FLOWN AT THE 1962 NATIONALS.

by DON DICKERSON & NORM BEELER

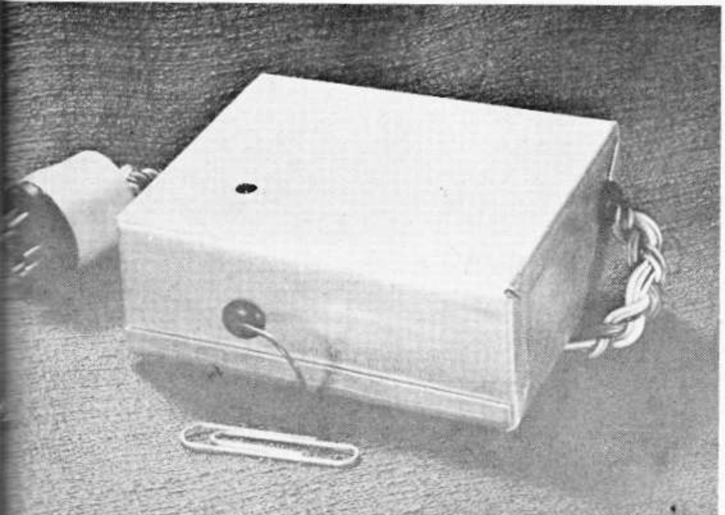


► This control system was developed by the authors to obtain maximum performance within the "Intermediate" category of the AMA rules. An airplane equipped with it won first place in Class II at the 1962 Nationals.

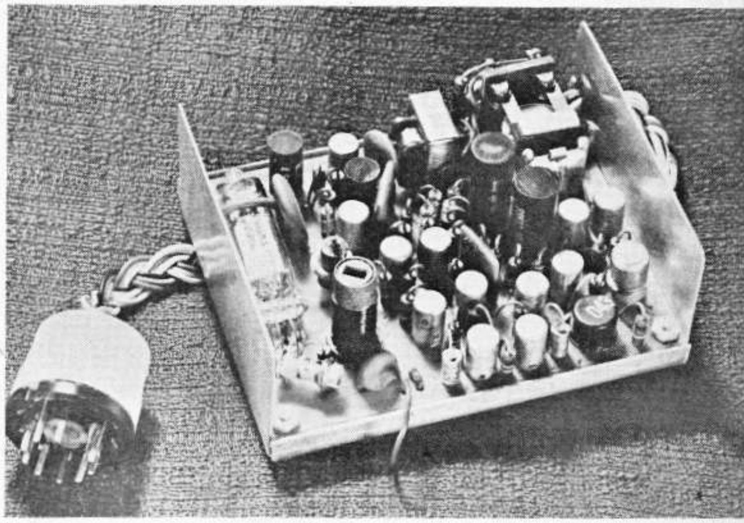
Operation is similar to many other pulse-width, pulse-rate schemes except that closed loop feedback servos and much higher pulse rates are used. The transmitter is modulated with a nominal 1,500 cps audio tone. Elevator is obtained by switching the audio tone on and off at a rate that is variable from about 30 to 50 cps. Neutral elevator corresponds to about 40 cps, full up to 48 cps, and full down to 32 cps. Rudder is obtained by varying the pulse width ratio (ratio of the tone on to tone off time during a pulse cycle) from 30/70 to 70/30. Neutral rudder corresponds to 50% tone on, left to 30% tone on, and right to 70% tone on. Neutral trim for rudder and elevator is accomplished by electrically varying the pulse width ratio and pulse rate corresponding to the control stick mechanical neutral. Fast engine speed is had by sending a steady tone; slow by sending unmodulated carrier. During throttle command, rudder and elevator control are surrendered, and the surfaces move toward neutral. This has very little effect on the flight of the airplane since the throttle reacts with no discernable time delay. Most types of system failures result in the throttle moving to low speed and the control surfaces to neutral; therefore, the system is predominately "fail safe."

Thus, two simultaneous proportional channels with trim plus a trimmable non-simultaneous channel are available.

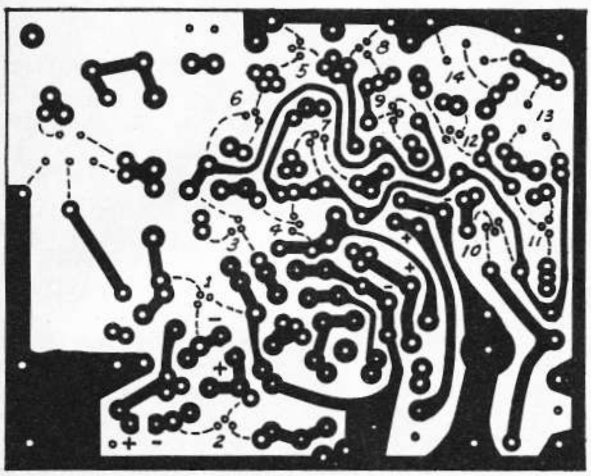
PROPORTIONAL SYSTEM



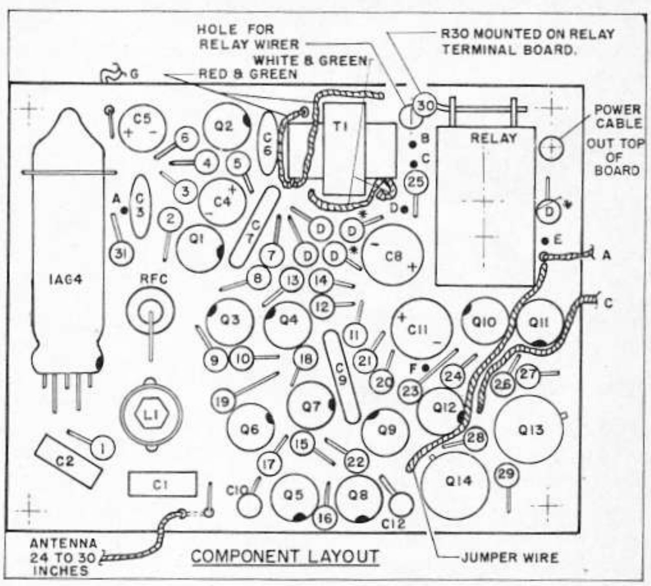
Receiver with dust cover in place—be certain to use grommets where-ever wires extend through the case—hole in top to reach tuning slug.



Dust cover removed—receiver well planned with all parts easily accessible—use metallic spacers when mounting receiver to P.C. board.



C13 across throttle control servo is not on P.C., but is across servo motor terminals.



With coupled ailerons and rudder and a modern airplane, performance approximates that of any available proportional or reed system and at considerably less cost. And, although it hasn't been used for it, this system should be a "natural" for pylon racing.

There is virtually no interaction between the rudder and elevator controls except for a small transient displacement of the elevator which occurs when the rudder is operated by rapidly snapping the control stick from side to side. This phenomena has no observable effect on the flight of the model; however, it is this "interaction" which permits this system to fly in Class II. AMA rules changes to eliminate the rather illogical "interaction" concept from the Class II category definition are likely to be promulgated in the near future. These changes are not likely to affect the ability of this system to remain a top contender in Class II; they will merely create more competition.

The greatest advantage of this system over those using dither, or "wiggle," type servos is that control surface "blowback" is not a problem. The feedback servos have ample power and precision to put the surfaces in any desired position and keep them there throughout the speed range of modern competition airplanes.

The throttle servo is simply a "Mighty Midget" with simple modifications for longer life and greater strength. All the servos will be fully described in the third article of this series. They are not difficult to build and cost a total of about $44. For those who do not wish to build the feedback servos, "Space Control" servos will work very well.

The second installment will describe the pulser-modulator stick box and the single tube amplifier required to couple it to the RF section of any ground based MOPA type transmitter such as Lorenz, WAG, and TTPW. The P/M makes use of a commercially available stick assembly and no machining is required, although a few holes must be drilled and a bit of file work performed. Cost to build is about $32.

This project is not recommended for beginners, for those without at least an elementary knowledge of electronics, or for those who are not capable of neat workmanship. Although not extremely difficult, building does require care, patience, and attention to directions. In (*Continued on page* 34)

B & D PULSATONE RECEIVER
Continued

addition, access to an audio signal generator, and oscilloscope, and a multimeter or VTVM is necessary for initial adjustment and for trouble shooting, if required.

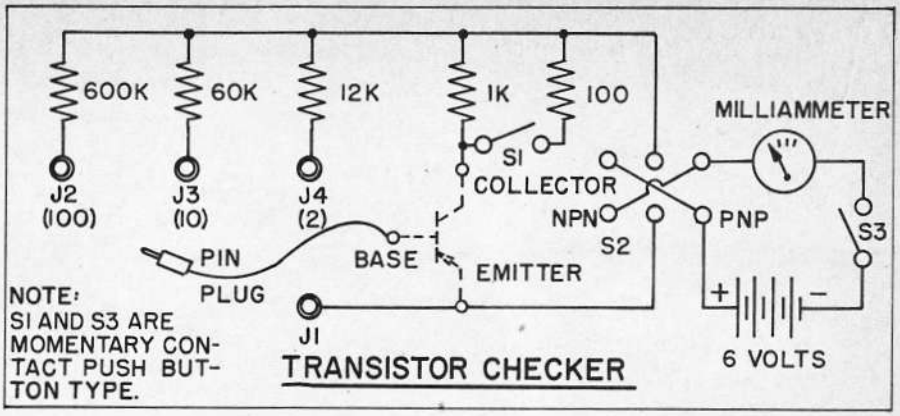
Some of the transistors *must* be selected for gain, namely Q2, Q13, and Q14. The transistor checker shown schematically in the drawings will accomplish this very simply and inexpensively. No construction details are given because the parts layout is not critical and most builders will want to use whatever parts they can resurrect from the junk box.

To use the transistor checker, simply place the PNP-NPN selector switch in the appropriate position, plug the transistor into the socket, and plug the pin plug into J2, J3, or J4. Next, close S3 and then S1, and read the meter. The DC current gain, or Beta, is the meter reading in milliamperes times the appropriate multiplying factor shown under the jacks on the schematic. Determine open base leakage by unplugging the pin plug and reading the meter with S3 closed. This value will range from a few micro-amps to .6 ma. or so for normal germanium transistors. Read leakage with base shorted to emitter by plugging the pin plug into J1 and closing S3. This value normally falls between four and twenty micro-amps for germanium transistors, and is just enough to barely nudge the needle of a O-1 ma. meter. If no reading can be obtained during any of the above tests, the transistor is open. If uniformly high readings of up to 6 ma. with S3 closed and up to 60 ma. with S1 also closed are observed, the transistor is shorted. Discard transistors with Betas much in excess of 200. Such abnormally high gain is often associated with excessive leakage.

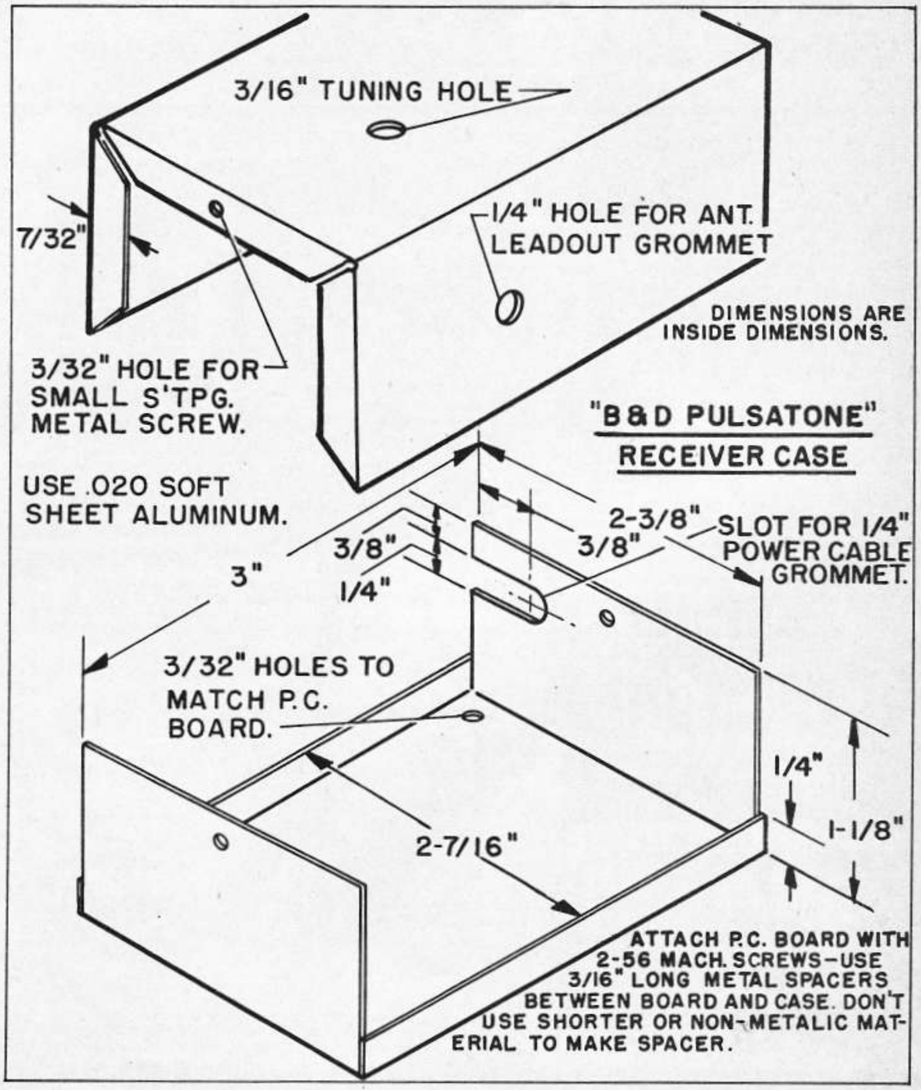
Q2 should have a Beta of 140 or higher with the pin plug in J2. Q13 and Q14 should have Betas in excess of 100 with the pin plug in J4. The total quantity of transistors required for this system is almost certain to yield enough transistors with sufficiently high gain for these positions. (The servos and P/M require a total of ten 2N1303 or 2N1305 and six 2N1302 or 2N1304 transistors.)

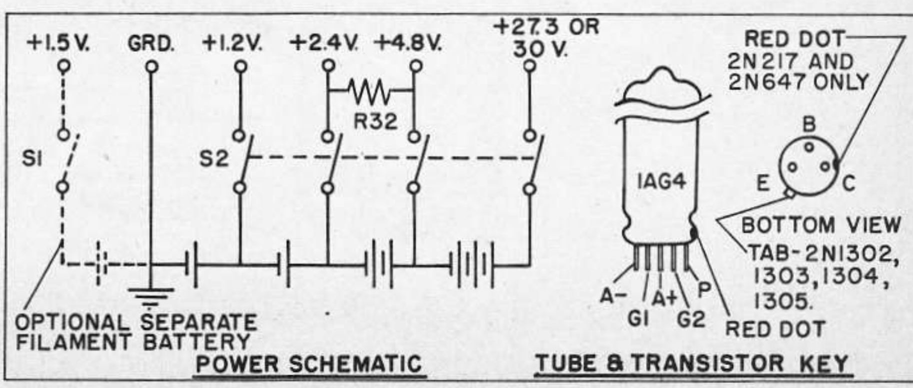
The receiver components cost about $40.00. When ordering parts, please stick to the parts list as there is nothing to be gained by substitutions except trouble. The 100 ohm "Gem" relay and the three etched circuit boards required for the entire system are available from Ace Radio Controls. Consult their Ads for prices.

Prepare the circuit board by trimming and squaring to 2⅜ by 3 inches and drilling (*Continued on page* 54)



TRANSISTOR CHECKER





Proportional Control

(*Continued from page* 34)

at each point indicated. Use a no. 68 drill and feed slowly to prevent crazing of the circuit board. It ordinarily isn't necessary to use a center punch; the holes in the conductors and the little copper "doughnuts" are sufficient to guide the drill. Now drill the larger holes used for mounting lugs, screws, power cables, etc. Check the board against the drawings for location, and against the actual parts for size. Slightly countersink the holes through which the leads of the electrolytic capacitors pass so that these parts will fit flat against the board. Remove what is left of the copper "doughnuts" and any other burrs. Scrub the board thoroughly with household cleanser and dry. The board is now ready for the mounting of components.

Wind the tuning coil with the number of turns and the size wire specified on the drawings. The coil is close wound and the first turn starts about 1/16 inch from the base of the form.

Prior to mounting any components, check them for continuity, proper resistance, and/or proper color coding as applicable. The highest resistance winding of the transformer is the primary, or 20K impedance, side. When checking electrolytic capacitors for shorts or opens with an ohmeter, observe proper polarity and bear in mind that electrolytics normally exhibit some leakage. Check all diodes for shorts and opens, and for a normal ratio of forward to back resistance.

Examine the relay to determine that (1) the screw holding the terminal board to the relay frame is tight, (2) the moving contacts bear against the N.O. contacts with nearly equal pressure, (3) that there is a gap equal to two or three thicknesses of bond paper between the armature and pole piece when the N.O. contacts are closed manually with very light force, (4) that with the relay energized at 4.8 volts, the armature bears against the pole piece and both moving contacts bear firmly against the N.O. contacts, and (5) that the relay pulls in somewhere between 3

(*Continued on page* 56)

Proportional Control

(*Continued from page* 54)

and 4 volts and drops out above 1.2 volts. Achieve No. 5 by adjusting spring tension only; don't tamper with contact spacing unless necessary to achieve 2 and 4. No. 3 is achieved by bending the moving contact arms, *not* by bending the fixed contacts.

Locate all components with fixed lead or lug spacing on the board to determine that the holes are properly spaced. Correct minor errors by enlarging the holes slightly and/or by bending leads a bit. Note that the relay moving contact lug nearest C8. must be bent sharply upward to avoid interference with C8.

The components may now be assembled to the board in this order: (1) all resistors except R17 and R30, (2) all capacitors except C2, (3) the tuning coil, RFC, and the transformer, (4) all diodes, (5) all transistors, (6) the relay and R30, (7) the jumper wires, power cable and plug, and (8) the tube. Place a ⅛ inch thick sponge rubber pad under the tube and hold down with insulated wire as shown in the photo. Work with great care and double check each step as it is performed. Observe electrolytic capacitor and diode polarity, and insert the emitter, base, and collector leads of the transistors through the correct holes.

Use a small, clean iron of about 37.5 watts and a good grade of small diameter radio solder such as "Ersin Multicore" for all soldering. Don't bend component leads over on the conductor side of the board except where indicated by the dashed lines. It isn't necessary and makes component removal extremely difficult in event of an error. Merely poke the wires through, solder, and snip off close to the board. It isn't necessary to use heat sinks on the transistor and diode leads if the leads are soldered clean and fast. After soldering is completed, remove the soldering flux with lacquer thinner and examine the board for any evidence of cold solder joints. Resolder any that look suspicious.

Set the receiver aside and bend up the aluminum case. The circuit board is fastened to the case with four 2-56 machine screws and is supported 3/16 inch above the case bottom with tubular spacers cut from 3/32 I.D. brass or aluminum tubing. *Do NOT* use non-metalic spacers, and do not make them less than 3/16 inches long.

The receiver is now ready for electrical checkout, but before power is applied, it is recommended that the entire receiver be checked against the schematic to familiarize the builder with the circuit and to disclose any mistakes in wiring. During checkout, the receiver is not mounted in the case.

Clip the leads of C2 to 1 inch and temporarily solder in place. Now connect a headset in series with an .01 MFD. capacitor between ground and the collector of Q2. (We bring a lead out through the power cable from the collector of Q2 specifically for check out use.) A loud, course, "rushing" noise (superregenerative "hiss") should be heard with the receiver connected to power. A 0-5 ma. meter inserted in the B-plus battery lead should indicate 1.5 to 2.0 ma.

In the presence of RF of the correct frequency from a transmitter or a grid dipper, rotate the tuning slug with a plastic tuning wand. A position will be found where the hiss disappears and is replaced with silence. If the RF is turned off, the hiss will return. The receiver is now tuned. If the tuning slug extends more than 1/32 inch from the coil form at the tuned position, remove it and cut off about one-third with a razor saw, replace, and retune. If the slug fits too loosely, place a piece of "Saran Wrap" or other very thin plastic over the open end of the form, replace the slug, retune, and trim away any excess plastic that squeezes from between the slug and the form.

Now lower the B-plus in 1.5 volt increments by placing 1.5 volt cells in series with the "B" battery with opposite polarity to lower the overall voltage until the hiss disappears. If superregeneration ceases, between 16 and 19 volts, operation is normal, and C2 can be permanently installed. If it ceases about 19 volts, increase C2; if it continues below 16 volts, reduce C2. Usually C2 will be either 22 mmf, 27 mmf, or 33 mmf. If an increase in C2 is indicated, and capacity as high as 39 mmf still isn't sufficient, reduce R2 to 22K. If a transmitter capable of 100% modulation at 1200 to 1700 cps is handy, it may be tuned in and the output of Q2 checked with an oscilloscope substituted for the headset and the .01 capacitor. The output should be a slightly clipped sine wave of about 38 to 40 volts peak to peak amplitude.

The "back end" of the receiver may now be partially checked out. Tack in a 12 K resistor for R17. Connect the output of an audio signal generator through a 100K resistor to the base of Q3 and the common to receiver ground. Connect an oscilloscope between the collector of Q4 and ground. With all power except B-plus connected to the receiver and the signal generator set to zero volts output at about 40 cps sine or square wave, gradually increase output until a clean square wave of 4.6 volts to peak amplitude appears on the scope. The relay, which should have pulled in solidly upon application of power, should now be de-energized. Now place a VTVM or a 10K per volt sensitivity or higher DC voltmeter between the output to the elevator servo and the 2.4 volt battery tap. The meter will read somewhere between plus and minus 2.4 volts. Vary the frequency until the meter reads zero volts. If this occurs between 38 and 42 cps, R17 may be permanently installed. If it occurs above 42 cps, increase R17, it below 38 cps, decrease R17. The correct value will likely be 10K, 12K, or 15K. When the frequency is varied plus or minus 7 or 8 cycles about the specific frequency, which gives zero volts output, the voltage should vary minus or plus .5 volts respectively.

Now reduce the frequency until the pulse omission detector relay begins to chatter. It should begin to chatter somewhere below 25 cps. Whenever pulsing is interrupted by opening the signal generator output lead, the relay should energize immediately. In the unlikely event that the relay chatters above 25 cps or has a discernable time delay between interruption of pulsing and pull in, correct by increasing or decreasing R22 respectively.

The remaining electrical checkout requires the use of the pulser modulator and will be covered in the next installment.

Some explanation of the power schematic is in order. The circuit as shown is for a 22.5 volt "B" battery. If a 30 volt battery is used, connect "B-minus" to ground instead of to 4.8 volts. A power converter would probably be O.K. but we haven't tried it.

The separate 1.5 volt filament cell is optional. If it is used, omit R31 and the jumper wire between R31 and the plus 2.4 volt connection on the relay terminal board and include a separate filament lead in the power cable. We tap the filament voltage off the servo batteries and have had no trouble, but we have been using 1.2 amp/hr. nicads. It is not known if this technique will cause difficulty when using smaller capacity cells with higher internal resistance. In any event, *DO NOT* simply tap off 1.2 volts for filament; this does not allow an adequate margin of safety. Filament drain is 40 ma. The purpose of R32 is to equalize the drain on the servo cells when a separate filament supply is not used. R32 is optional.

Sintered plate nickel cadmium cells of 450 ma/hr capacity or greater are required for the 4.8 volt servo and receiver supply. Other types of cells probably will be satisfactory. Drain on the servo cells is a steady 50 ma. excluding filament drain except during command when the drain is higher. 450 MA/HR cells should give at least three hours flying time between charges even with the filament power taken from them.

Switch S2 may be a single 4PST type or two 2PST switches mechanically connected such that both are operated at once. *DO NOT* use separately actuated switches for S2 unless control surface linkages are arranged to permit 360 degree rotation of the servo output shafts.

No, the relay does not pulse. It remains dropped out except during throttle command. Its purpose is to return the servo inputs to the plus 2.4 volt reference during throttle command and to disable the throttle servo amplifier during normal pulsing. The receiver weighs 4 oz. with case, cable, and plug.

COMPONENT NOTES

All resistors—Ohmite ¼-watt (Allied)
C1, C2—Centralab type TCZ (Allied)
C3—Sprague type D10 (Allied)
C4, C5, C8, C11—IEI electrolytic, printed circuit type (Ace)
C6—Sprague type D50 (Allied)
C7—Sprague type 5C11 (Allied)
C9—Sprague type 5C9 (Allied)
C10, C12—Texas Instrument type 475F-P010A4 (Allied) This is a tantalum capacitor.
C13—Any disc ceramic capacitor.
S2—4PST Switch, Slide Type with Knife Contacts (Ace)

RFC—10 micro-henry RCA for 50 mc. (Ace) 20 micro-henry Miller 6152 for 27 mc. (Ace)
Coil Form—¼" I.D. paper phenolic for 27 mc (Ace) CTC type SP11-I-2L ceramic for 50 mc. (Newark Electronics)
Diodes—IN34A (Allied)
Relay—Gem, DPDT, 100 ohms (Ace)
Tube—IAG4 (Allied)
Transformer—ST11, JE102T, CR60 (Ace) The CR60 can also be obtained from Burnstein-Applebee under Part #170659 for 89¢.
Printed Circuit Board—(Ace)
Transistors—(Allied)
NOTE: Component values listed in the receiver schematic.

All Allied parts are listed in their industrial catalogue, available free upon request.

At Allied Electronics Corp., 100 N. Western Ave., Chicago, Ill.