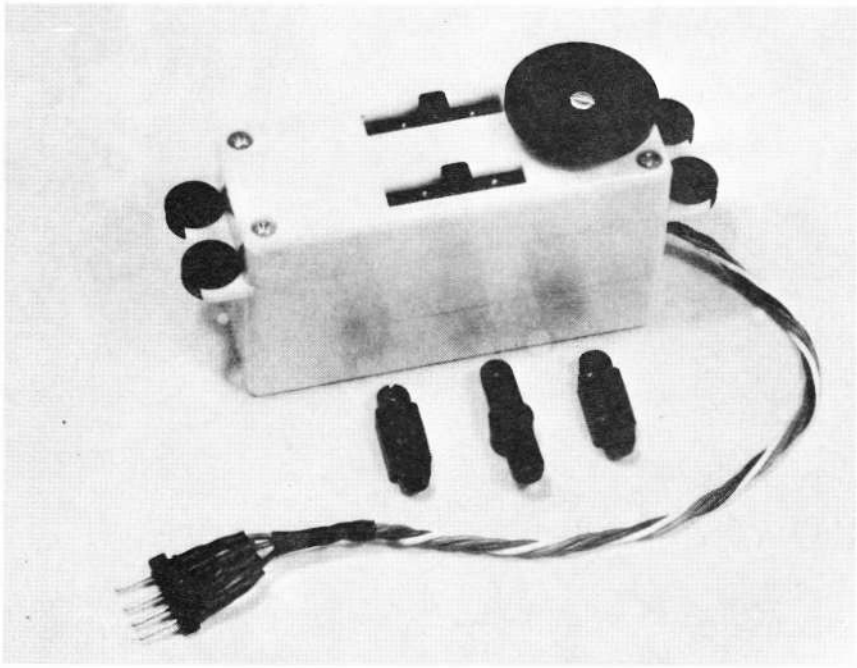


CLASSIC 9 SERVO

By ED THOMPSON
RCM TECHNICAL EDITOR

THE LATEST "UP-DATE" FOR OWNERS OF THE RCM CLASSIC PROPORTIONAL SYSTEM

GENERAL

The Classic 9 servo is an extremely rugged servo with very high torque and excellent mechanical strength. It utilizes a feedback pot element that should provide trouble-free service for the life of the system. A choice of rotary or dual linear output is provided. The motion of the rotary output is opposite of the linear outputs, enhancing its versatility and also allowing maximum installation flexibility. Lubrication of the servo is not necessary or advised.

The Classic 9 servo features an in-depth designed amplifier which reverses the trend toward minimum acceptable amplifiers in the small servo era of digital radio control systems. It provides big servo power with small physical size. The amplifier utilized is the same as used in the Classic/Orbit PS-2 to provide maximum performance with the advantages of the small, versatile and unexcelled Kraft KPS-9 servo mechanics with the added plus of a resistance feedback element of proven reliability.

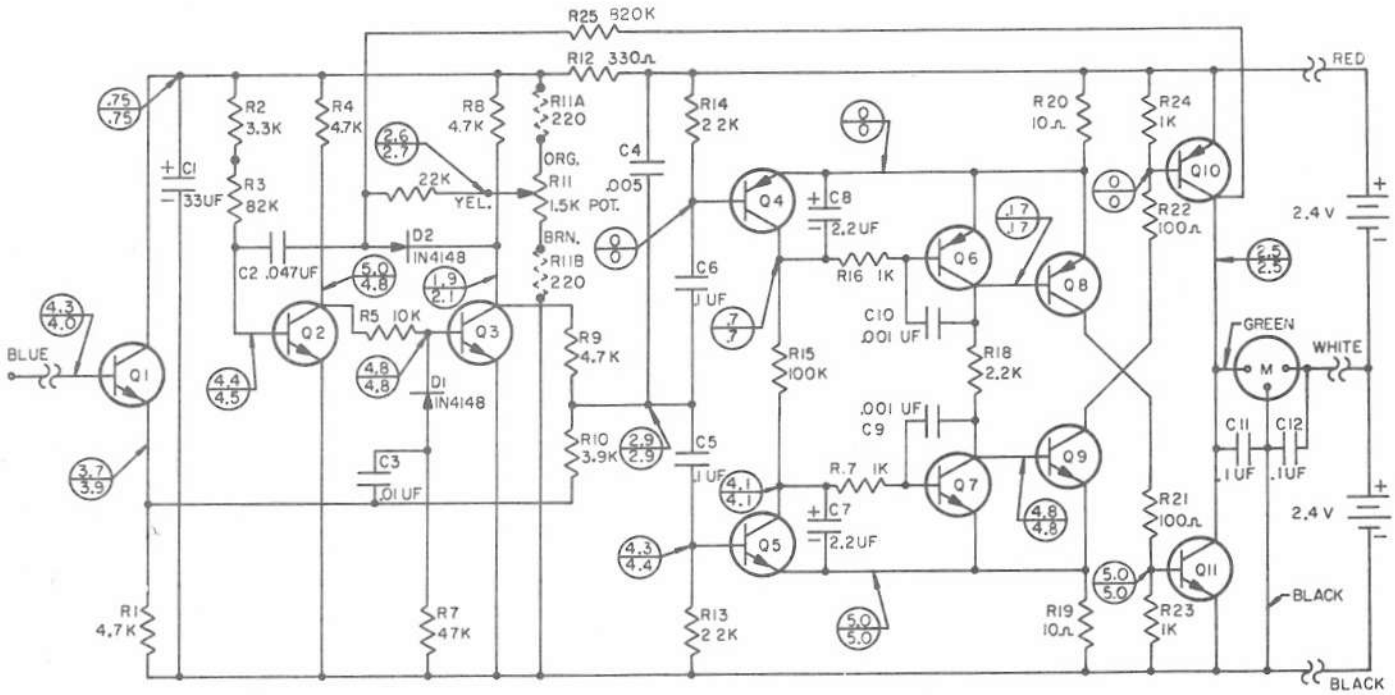
THEORY OF SERVO AMPLIFIER

Refer to the block diagram and schematic for the following discussion of the servo amplifier theory.

The Classic decoder supplies a positive pulse of variable duration, every 20 MS, to the servo amplifier input. The input pulse is variable from 1 to 2 MS and is controlled at the transmitter. The servo amplifier has a variable pulse-width reference generator. The reference generator's pulse width is controlled by the output gear position via a coupled potentiometer. The incoming pulse width is compared with the reference generator's pulse width. When the incoming pulse width and the reference generator pulse width do not agree an error pulse is generated which causes the motor to turn. The motor turns the output gear in a direction to cause the reference generator's pulse width to agree with the incoming pulse width. When both pulse widths agree the servo amplifier is "nulled" and the servo motor stops. The incoming pulse and the reference generator's pulse width are compared every 20 MS. A "pulse stretcher" is used to provide motor voltage continuity and smooth servo action. Q8, 9, 10 and 11 form a complimentary-symmetry amplifier. The collectors of Q10 and 11 are connected, through the motor, to the battery center tap. If neither Q8 or 9 are conducting, the amplifier is quiescent. When either Q8 or 9 conducts it will cause its (pair) transistor to conduct. When either Q8 or 9 conducts, its associated output transistor will conduct and the motor will operate. Electrical damping is used to enhance servo smoothness by preventing excessive mechanical overshoot.

The incoming pulse is applied to the base of Q1, Q1 is an impedance converter (emitter follower) which isolates the decoder output from the low impedance summing junction. The incoming pulse causes the voltage at the top of R1 to rise and fall in phase. The leading edge of this positive-going pulse supplies the trigger for the reference generator (Q2 and 3) via C3 through D1 to the base of Q3. This positive-going signal is also applied to R10 which forms the lower half of the summing junction. R9 forms the top half of the summing junction and the reference generator supplies a negative-going pulse at this point (collector of Q3). The positive pulse width applied to the lower half of the summing junction is determined by the transmitter via receiver and decoder. The width of the negative pulse applied to the top half of the summing junction is dependent upon the timing of the reference generator (One-shot multivibrator) and is determined by the setting of R11. R11 is coupled mechanically to the output gear and as the motor turns the timing of the reference generator is varied.

If the incoming pulse from the decoder, supplied to the lower half of the summing junction, is longer in width than the pulse supplied by the reference generator a positive differential will remain at the junction of C5 and C6 after the reference generator has returned to its quiescent state. This will cause a positive pulse to be coupled via C5 to the base of Q5. The collector of Q5 will then go negative and remove forward bias from Q7. Q7, cutting off, will forward bias Q9 which will forward bias Q10 causing it to conduct. The voltage at the junction of Q10 and Q11's collectors will go positive and the motor will turn having a positive voltage on its left terminal and a negative voltage on its



ALL RES. 1/4W 10%
ALL CAPS IN MFD.
C2 MYLAR 10%; C1, C7, C8 ARE TANTALUM 20%
ALL OTHERS DISC. CERAMIC. ALL CAPS. ≥ 10 VOLTS
Q1,2,3,5,7,9 – SPS 400K (M400) MOTOROLA
Q4,6,8 – SPS 401K MOTOROLA
Q10 – MPS 6534 MOTOROLA
Q11 – MPS 6531 MOTOROLA

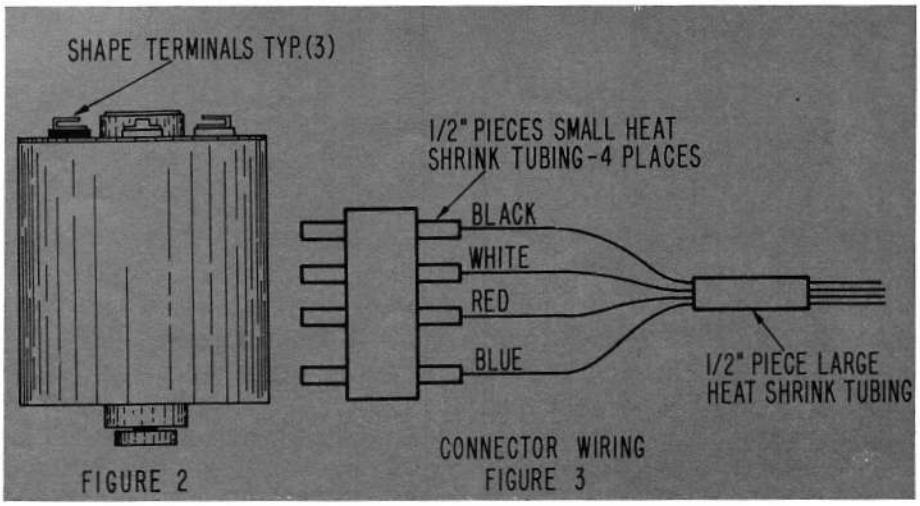
ALL VOLTAGES TAKEN WITH RED (POS.) METER PROBE CONNECTED TO RED SERVO POWER WIRE

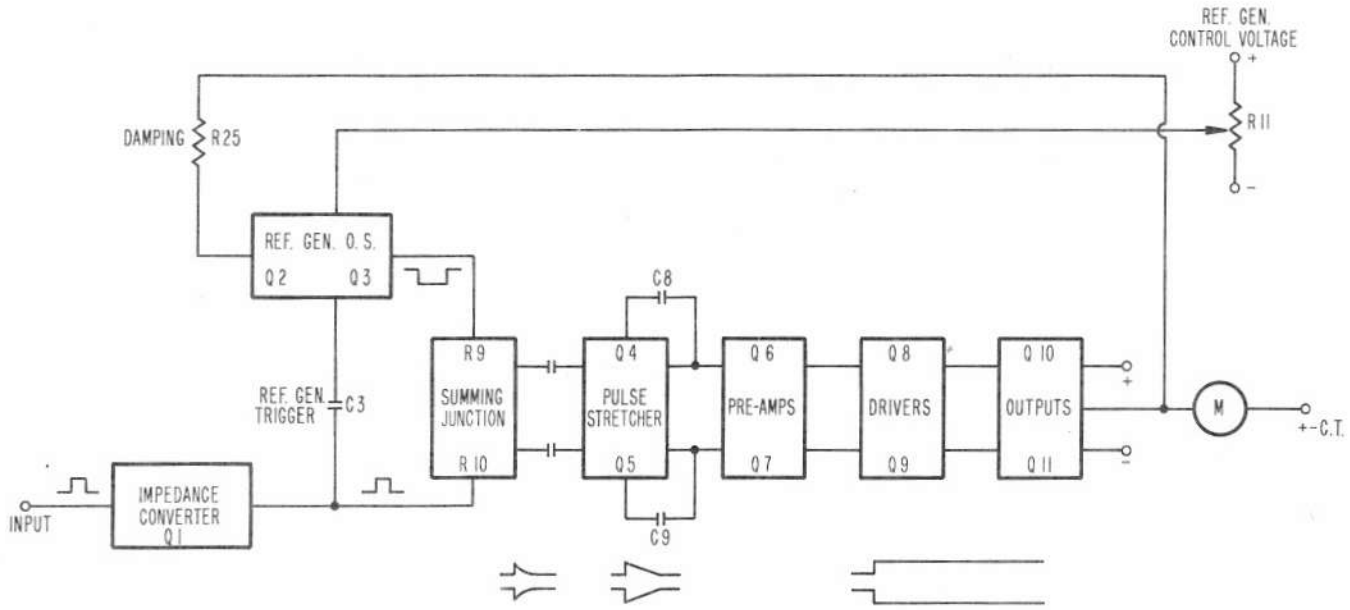
(4.3 / 4.0) VOLTAGE ABOVE THE LINE WITH TX OFF – RX & DECODER ON
VOLTAGE BELOW THE LINE WITH TX & RX – DECODER ON

right terminal. The feed-back element is coupled directly to the motor (via gears) and will turn in a direction to lengthen the reference generator's pulse width. When the motor has turned the output gear, which in turn turns the reference generator potentiometer sufficiently to cause the negative pulse width at the top of the summing junction to be equal to the positive pulse width applied to the bottom of the summing junction, a "null" condition will exist. In a null condition the summing junction differential will be below the conducting point of either Q4 or 5. This will remove motor driving voltage and the servo will stop in that position. The pulse supplied via C5, to cause the motor to turn, was very short in duration and pulse stretching was needed to supply continuous voltage to the motor. This was accomplished with C7. When the collector of Q5 went negative it discharged the capacitor through a very short time constant (collector/emitter junction of Q5). When the summing junction pulse decayed below the conducting point of Q5, C7 charged through a much longer time constant (base/emitter junction of Q7 and R15) and pulse stretching occurred. The time constant of the pulse stretcher was selected to remove forward bias from Q7 during the resting period between pulse trains which occur every 20 MS.

The emitters of Q5, 7 and 9 are tied together to provide degeneration allowing higher initial amplifier gain and to reduce the possibility of amplifier "overhang" which would cause Q10 and 11 to conduct simultaneously. The action necessary to cause the servo to turn in the opposite direction is very similar and will occur when the incoming pulse width is shorter than the reference generator's pulse width. In this case a negative pulse will be produced at the output of the summing junction and will forward-bias Q4 via C6. Q4 conducting will discharge C8 and Q6 will cutoff, forward biasing Q8; this will forward bias Q11 and the motor will then turn with the left side being negative with respect to its right side. The motor then turns the servo gears which turns R11, in a direction to decrease the reference generator's pulse width until the servo is nulled.

Electrical damping is provided via R25 to control the output gear overshoot caused by mechanical inertia when the servo approaches a null condition. R12 and C1 provide decoupling to the reference generator portion of the servo. R11a and R11b allow means of adjusting the total servo travel for a given input pulse width change. The reference generator is a one shot multivibrator and its operation was extensively covered in the Digitrio series of articles which appeared in RCM. Silicon transistors





are used in the output stage of the servo amplifier to eliminate the possibility of thermal runaway. C11 and C12 filter electrical noise produced by the motor.

SERVO MECHANICS ASSEMBLY

Assemble the mechanical portion of the servo as follows:

( ) Lay the servo parts out on the bench and study the pictures of the servo assembly. Read the instructions over a couple of times. Mentally put the servo together with the aid of the pictures.

( ) (See Photo 1). Pick out the feedback pot housing and the feedback pot wiper assembly. Place the wiper assembly in the housing and check for fit. The wiper assembly must turn freely with no binding; if not, the housing should be reamed out slightly - a Dremel tool No. 194 works nicely for this purpose. When finished remove the pot wiper assembly.

( ) Select the two small sheet metal screws; mount the feedback pot housing to the inside of the middle servo section using these screws. (See Photo 2).

( ) Press the motor in place in the middle servo section; (see figure 1) for position of solder lugs.

( ) Inspect the pot wiper assembly for dirt or malformed contacts and insert it in the pot housing. Note the wiper assembly comes with preformed contacts to give the proper wiping tension - do not adjust. If it is suspected that the contacts are not formed correctly, check it against the wiper from another servo if available.

( ) Being careful to avoid wiper damage, hold the wiper assembly in place and press the C-ring on the wiper shaft in the slot provided. With a pair of pliers, squeeze the C-ring on the shaft to insure secure fit.

( ) The wiper shaft is flatted on one side to key it to the output gear; install the output gear.

( ) Inspect the feedback pot element for dirt and install it with the two small machine screws and fiber washers. See figure 1 for proper orientation of the feedback element solder lugs. Do not overtighten the hold-down screws.

( ) Clip the three feedback elements to approximately 1/8", bend them back to a 45° angle and tin with solder.

( ) Form the motor solder lugs as shown in (figure 2) and tin with solder.

( ) Find the three gears and three gear shafts. Assemble them as shown in (Photos 3, 4, and 5).

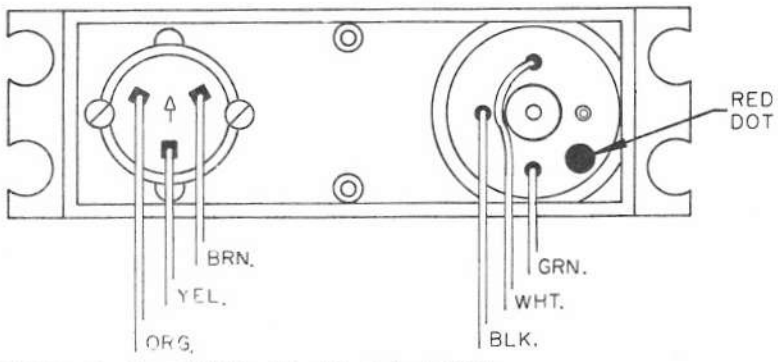
( ) Assemble the rack gear platform as shown in (Photo 6).

( ) Carefully fit the top cover in place and hold down with two or more short Phillips head screws. Note the two output rack gears will be installed later during servo alignment.

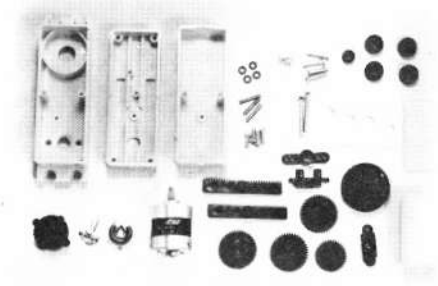
( ) Check the PC board for fit in the bottom servo section as shown in (Photo 7). File the board slightly if necessary for a proper fit.

( ) Place the servo mechanics aside until the PC board is completed.

( ) Inspect the leads of all the capacitors for flashing. Scrape these leads clean of flashing up to the

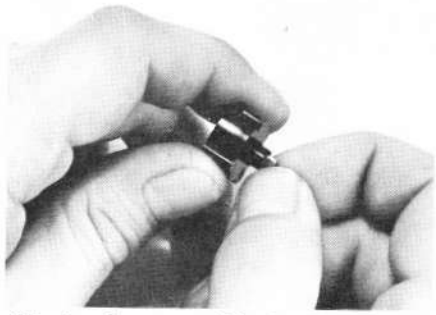


NOTE: 1. ALL WIRES GO TO P.C. BOARD.
2. WIRED FOR CCW ROTATION OF WHEEL OUTPUT WHEN VIEWED FROM TOP SIDE - WITH RIGHT AILERON SIGNAL.
3. REVERSE POSITION OF ORG. & BRN. ALSO GRN. & WHT. FOR CW WHEEL ROTATION.



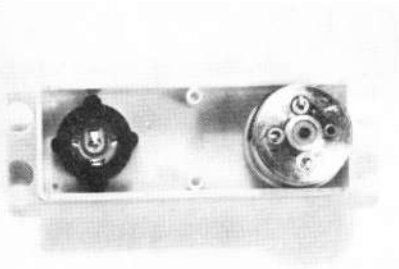
Servo mechanics parts - Kraft KPS 9 with F.B. pot.

(1) Wiper assembly installed in feedback pot housing.

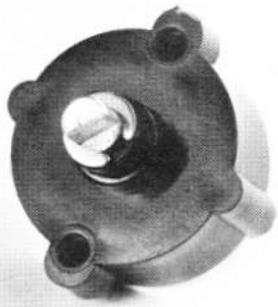


Check wiper assembly for fit in F.B. pot housing.

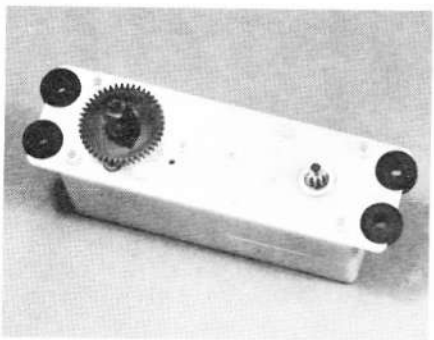
Dremel tool 194 used to ream F.B. pot housing if necessary.



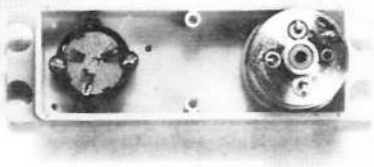
(2) F.B. pot housing and motor installed. Wiper assembly added after housing is installed.



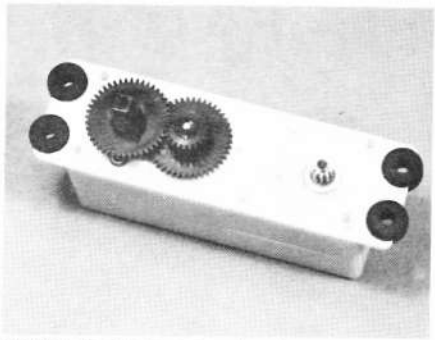
Close-up of wiper shaft retainer.



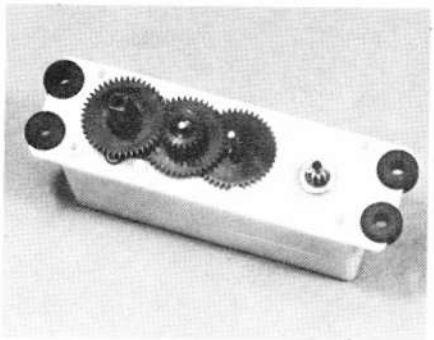
Output gear in place - note F.B. pot housing mounting screw and fiber washer under gear.



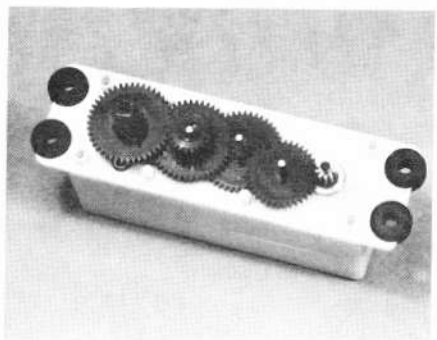
Feedback pot element in place - arrow should point as shown in figure 1.



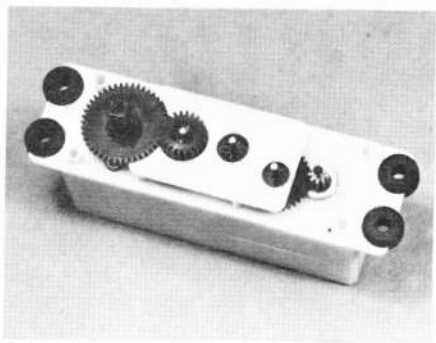
(3) Rack driving gear in place.



(4) 2nd intermediate gear in place.



(5) 1st intermediate gear in place.



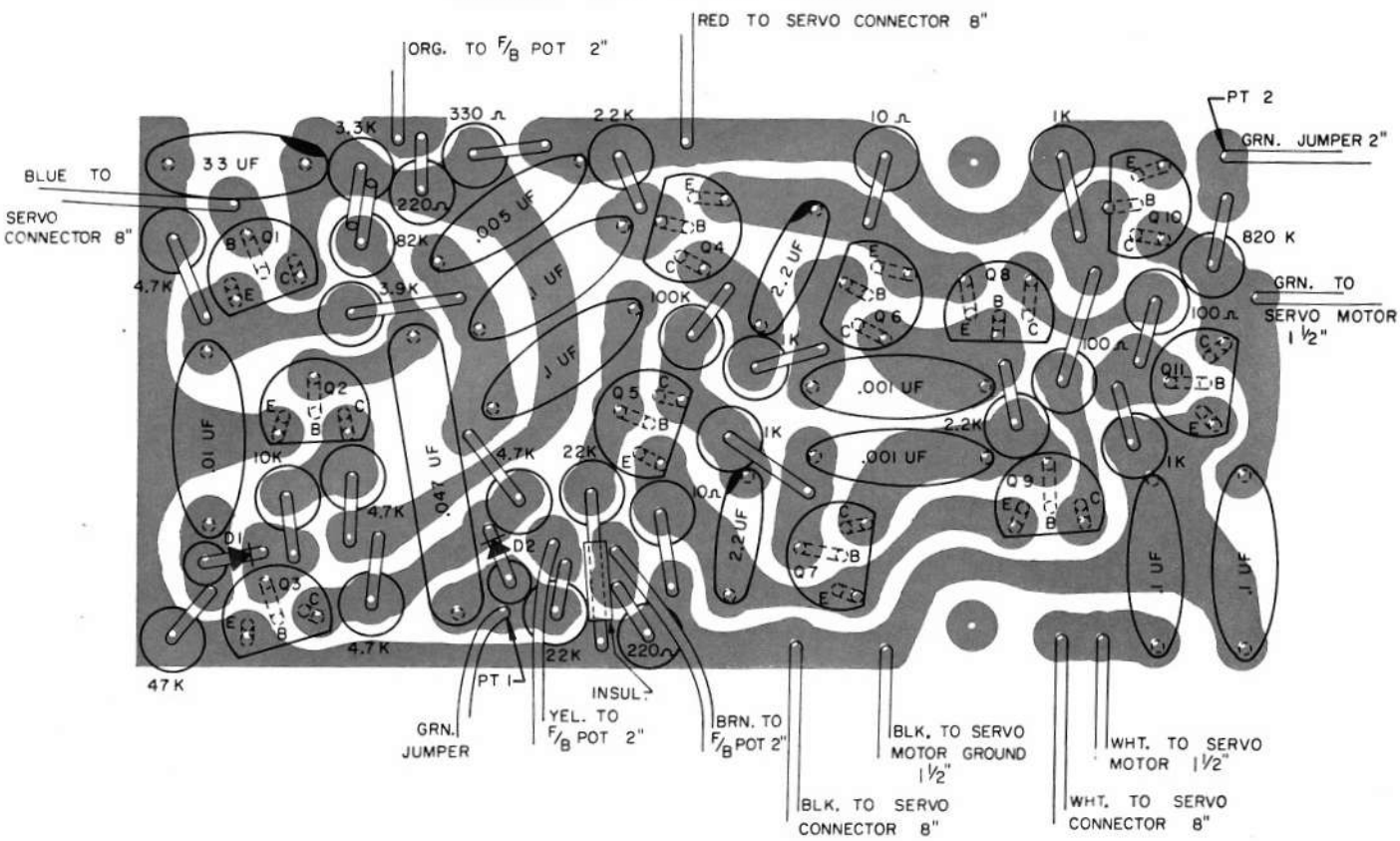
(6) Rack gear platform in place.

main portion of the capacitor body to prevent cold solder joints when the caps are installed.

( ) As the PC board assembly progresses check for adjacent component lead "shorting." If in doubt use a piece of insulating tubing over one of the suspected leads.

( ) When installing the 33 mfd tantalum capacitor (C1) watch the clearance between it and the 3.3K resistor (R2) to its right. Some of the 33 mfd caps may have a "blob" requiring slight leftward placement of the capacitor.

( ) Note that the top leads of the 3.3K (R2) and 82K (R3) resistors



are bent over and soldered together.

( ) Here is a well-worn, modified, sentence to help you remember the color code.

Word	Color	Number
(Read Down)		
Bad	Black	0
Boys	Brown	1
Ravage	Red	2
Our	Orange	3
Young	Yellow	4
Girls	Green	5
But	Blue	6
Violet	Violet	7
Goes	Grey	8
Wanting	White	9

PC BOARD ASSEMBLY

(See construction Overlay)

( ) Check the electronic parts against the parts list.

( ) Install the 33 mfd tantalum capacitor (C1) at the upper left corner of the PC board (observe polarity).

( ) Install the .047 mylar capacitor (C2) at the left side of the PC board.

( ) Install the .01 mfd disc capacitor (C3) at the left side of the PC board.

( ) Install the .005 mfd disc capacitor (C4) above the .047 mylar capacitor.

( ) Install the two .1 mfd disc capacitors (C5 and 6) below the .005 mfd disc capacitor.

( ) Install the two 2.2 mfd tantalum capacitors (C7 and 8) at the center of the PC board (observe polarity).

( ) Install the two .001 mfd disc capacitors (C9 and 10) at the center of the PC board.

( ) Install the two .1 mfd disc capacitors (C11 and 12) at the lower right corner of the PC board.

( ) Install diode D1 at the lower left side of the PC board (the bar end of the diode should be facing up).

( ) Install diode D2 at the lower right side of the .047 mylar capacitor (the bar end of the diode should be facing up).

( ) Install the four 4.7K resistors (R1, 4, 8 and 9).

( ) Install the 3.3K resistor (R2).

( ) Install the 82K resistor (R3). (The top lead of these resistors (R2 and R3) are soldered together.)

( ) Install the 10K resistor (R5).

( ) Install the three 22K resistors (R6, 13, 14) - use a 1/4" length of insulating tubing over lead of the 22K resistor shown below Q5.

( ) Install the 47K resistor (R7).

( ) Install the 3.9K resistor (R10).

( ) Install the 330 ohm resistor (R12).

( ) Install the 100K resistor (R15).

( ) Install the four 1K resistors (R16, 17, 23 and 24).

( ) Install the 2.2K resistor (R18).

( ) Install the two 220 ohm resistors (R11a and R11b).

( ) Install the two 10 ohm resistors (R19 and 20). Color code br., blk., blk. Don't confuse these with the 100 ohm resistors - color code br., blk., br.

( ) Install the two 100 ohm resistors (R21 and 22).

( ) Install the 820K ohm resistor (R25).

( ) Install the six M400 NPN transistors (Q1, 2, 3, 5, 7 and 9). Refer to the overlay and insure that the flat side of transistors are as shown.

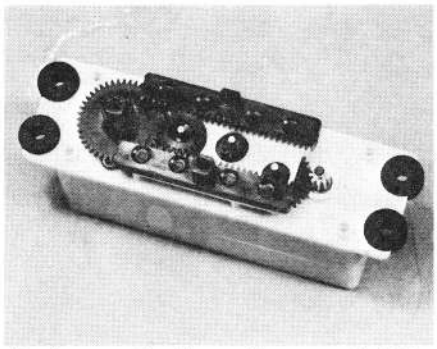
( ) Install the three PNP SPS401K transistors (Q4, 6 and 8). Refer to the overlay and insure that the flat side of the transistors are as shown.

( ) Install the PNP MPS6534 transistor (Q10).

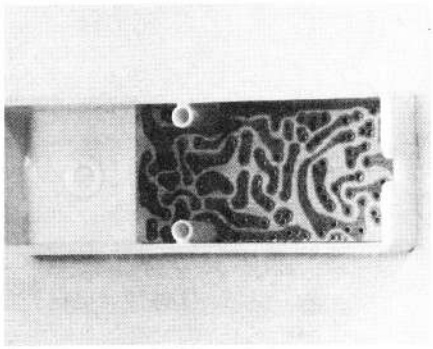
( ) Install the NPN MPS6531 transistor (Q11).

( ) Install the 8" length of black hook-up wire at the lower side of the PC board.

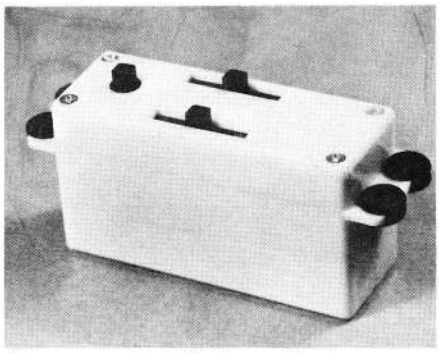
( ) Install the 2" piece of brown



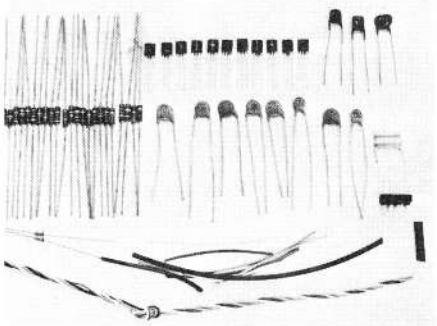
Rack gears in place - these are installed during servo alignment.



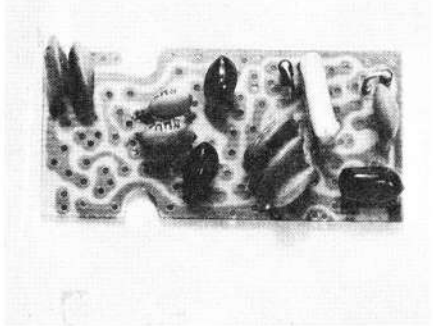
(7) Checking PC board fit.



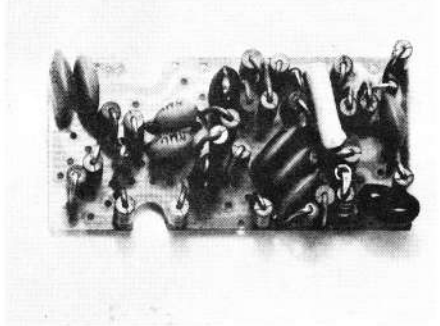
Top cover installed - rack gears are installed during servo alignment.



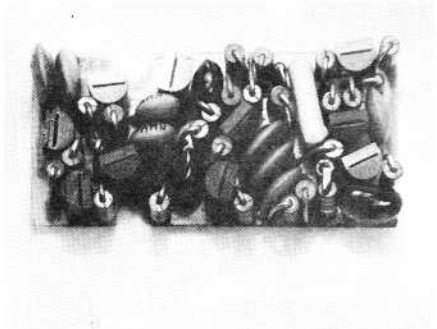
Electronic parts for Classic 9 servo.



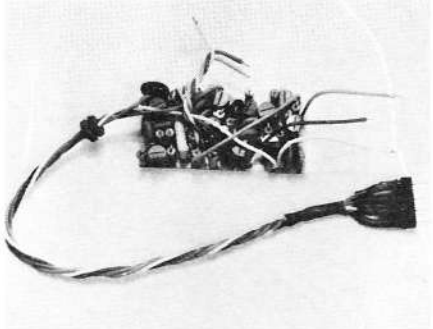
Capacitors installed on PC board.



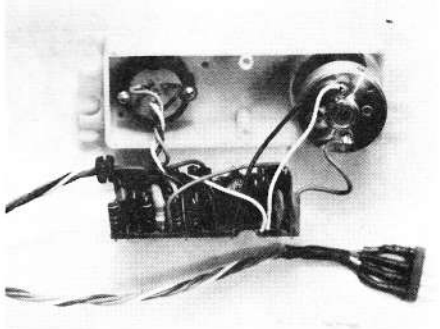
Caps, resistors and diodes installed on PC board.



All electronic parts installed on PC board.



PC board wired and ready for interconnecting with servo mechanics.



PC board and servo mechanics (interwired).

hook-up wire at the bottom of the PC board.

( ) Install the 2" piece of orange hook-up wire at the top of the PC board.

( ) Install the 8" piece of blue hook-up wire at the left side of the PC board.

( ) Install the 2" piece of yellow hook-up wire at the lower side of the PC board.

( ) Install the 8" piece of red hook-up wire at the top of the PC board.

( ) Install the 1-1½" piece of green hook-up wire at the right side of the PC board.

( ) Install the 1-1½" piece of black hook-up wire at the bottom of the PC board.

( ) Install the 1½" piece of white hook-up wire at the lower right side of the PC board.

( ) Install the 8" piece of white hook-up wire at the lower right side of the PC board.

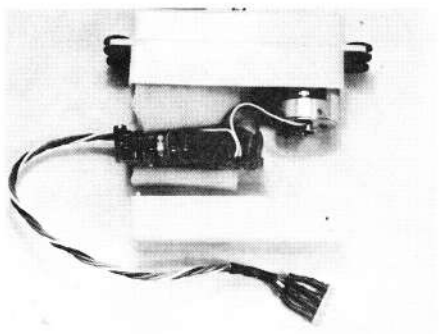
( ) Install the 3" length of green hook-up wire between lands labeled PT1 and PT2.

( ) Flat the solder mounds on the copper side of the PC board to approximately 3/64-1/16" and clean with acetone or dope thinner to remove all trace of solder flux and foreign material.

( ) Check the component side of the PC board for adjacent lead shorts and gently move components where necessary.

( ) Check the copper side of the PC board for solder land bridges making corrections as necessary.

The PC board is now completed.



Packing PC board into servo mechanics - note foam under and over PC board.

INTERWIRING THE PC BOARD AND SERVO MECHANICS

( ) Route the 8" pieces of red, white, black and blue hook-up wire

together over the left end of the PC board and twist them together.

( ) Slide the small grommet over the four 8" pieces of wire.

( ) Clip the ends of the servo wires to equal lengths and install the servo connector as per drawing. Use a 1" piece of large heat-shrink tubing over the four wires and a 1/2" piece of small heat-shrink tubing over each individual lead when installing the connector. Strip and tin each conductor 3/16".

( ) Strip 3/32", tin, twist together and solder the brown, orange and yellow wires to the feedback pot as shown in figure 1.

( ) Strip 3/32", tin (don't twist) and solder the 3" green, white and 4" black wires to the motor lugs as shown in figure 1.

Note: Electrical checks should not be necessary if care was used while building and wiring the servo. Voltage checks can be performed by comparing voltages with those shown on the schematic. The voltages shown below the line were taken with a transmitted center signal (1.5 MS). The voltages shown above the line were taken without a transmitted signal and with the servo centered. All voltage readings were taken with a 20K ohm/volt meter with the red (positive) test lead connected to pin 2 (red) of an unused decoder servo connector. All voltages may vary +– 20%.

SERVO ALIGNMENT

A properly aligned transmitter and receiver/decoder will be needed for servo alignment. The output wheel should be installed on the servo (do not install the linear racks on the servo at this time).

( ) Connect the servo to the channel 1 decoder output. Channel 1 can be identified by the brown signal lead going to pin 1.

( ) Turn on the transmitter and receiver/decoder. The servo should run to a position determined by the transmitted signal. Operate the transmitter stick controlling channel 1 and verify proper servo operation. Allow the transmitter stick to self-center and center the corresponding trim lever. If the neutral position of the output wheel is not exactly centered, the feedback element must be adjusted. The feedback element can be rotated the amount necessary to center the output wheel, by using the tips of a pair of small, long-nosed pliers, after loosening the feedback element hold-down screws.

( ) Install the linear output racks on the servo.

( ) Check servo throw by moving the transmitter control stick and trim lever alternately to both extremes.

( ) Mount the PC board using a 1/8"-3/16" thick piece of foam padding in the bottom cover, under the PC board, and a 1/2" piece of foam padding over the PC board.

( ) Paying particular attention to the servo motor wires to prevent pinching and ensuring that no wires are between mating surfaces, tighten the bottom cover in place with the two long Phillips head screws.

( ) Install grommets and your choice of wheel, lever, etc.

The servo is now complete.

Note: The direction of servo travel may be reversed by reversing both white and green motor wires and brown and orange feed-back pot wires. Servo centering will probably be necessary after rewiring.

(continued on page 54)

PARTS LIST – CLASSIC 9 SERVO

ITEM	DESCRIPTION	PART NO.	MFG. OR SOURCE
	Capacitors		
C1	33 mfd, 20% tantalum	TSD2-6-336	Semcore
C2	.047 mfd, 10% mylar	C280AE/A47K	Amperex
C3	.01 mfd, 20% disc	C069B160E103M	Sprague
C4	.005 mfd, 20% disc	C023B101E502M	Sprague
C5, 6, 11, 12	.1 mfd, +80-20% disc	DD600BC	Murata
C7, 8	2.2 mfd, 20% tantalum	TSD1-20-225	Semcore
C9, 10	.001 mfd, 20% disc	SM.001	RMC
	Diodes		
D1, 2	Diode, silicon signal	1N4148	ITT
	Resistors		
R1, 4, 8, 9	4.7K 1/4W, 10%		IRC or Ohmite
R2	3.3K 1/4W, 10%		IRC or Ohmite
R3	82K 1/4W, 10%		IRC or Ohmite
R5	10K 1/4W, 10%		IRC or Ohmite
R6, 13, 14	22K 1/4W, 10%		IRC or Ohmite
R7	47K 1/4W, 10%		IRC or Ohmite
R10	3.9K 1/4W, 10%		IRC or Ohmite
R11	1.5K variable (supplied w/servo mechanics)		
R11a, 11b	220 ohm, 1/4W, 10%		IRC or Ohmite
R12	330 ohm, 1/4W, 10%		IRC or Ohmite
R15	100K 1/4W, 10%		IRC or Ohmite
R16, 17, 23, 24	1K 1/4W, 10%		IRC or Ohmite
R18	2.2K 1/4W, 10%		IRC or Ohmite
R19, 20	10 ohm 1/4W, 10%		IRC or Ohmite
R21, 22	100 ohm 1/4W, 10%		IRC or Ohmite
R25	820K 1/4W, 10%		IRC or Ohmite
	Transistors		
Q1, 2, 3, 5, 7, 9	NPN, silicon	M400 or	Royal Elec.
		2N4124	Motorola
Q4, 6, 8	PNP, silicon	SPS401K or	Royal Elec.
		2N4126	Motorola
Q10	PNP, silicon	MPS6534	Motorola
Q11	NPN, silicon	MPS6531	Motorola
	Miscellaneous		
Servo mechanics (Kraft KPS 9 w/resistance F.B. element)			Royal Elec.
Hook-up wire No. 26, stranded			Royal Elec.
Foam padding, 2 pieces (to mount PC board)			Royal Elec.
Heat-shrink tubing			Royal Elec.
Male connector, previously listed in decoder parts list			Royal Elec.
PC board (etched)			Royal Elec.
Insulating tubing No. 24 (2")			Royal Elec.

A complete kit of parts or individual parts available from: ROYAL ELECTRONICS, 2101 South Leyden, Box 22204, Denver, Colorado 80222.