THE ROTARY DRIVER SYSTEM

By Harley Michaelis, LSF 023- Updated 4/14/11

NOTE: The following document was written for use with the 1999 injection-molded Kimbrough couplers and solid wire drive shafts. The couplers are still available and regularly used in some applications, so this document is being left intact for reference.

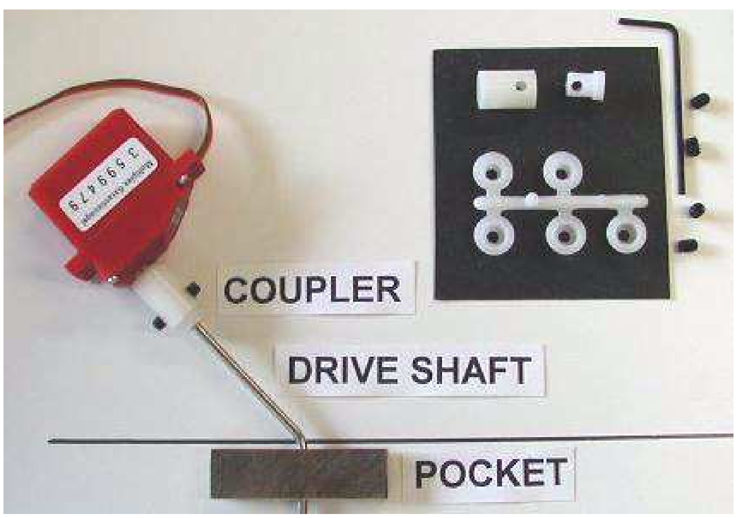
A new, G2-USA Made RDS with a refined coupler and which provides the option of using lighter and stiffer, telescoping SS hypo tubing drive shafts is now available with an extensive line of new hardware. The link below will take you directly into full details about this new RDS.

http://augiemckibben.tripod.com/sitebuildercontent/sitebuilderfiles/Gen_2_RDS.pdf

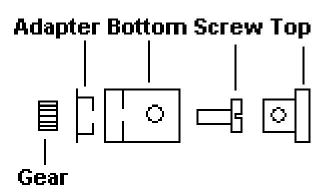
RDS mission statement: "To make the wings of RC air craft clean, quiet, stealthy, more beautiful and without the parasitic drag of external hardware, to fly at their maximum aerodynamic potential."

The RDS involves no output arms, horns, clevises, threaded rods, protruding well covers, etc. There's nothing to catch on things & cause drag & noise. Properly fabricated & installed, no slop or bind is contributed by the system. Full, easy, expected deflections are provided, unless stiff hinging or other structure inhibits it. It can be used to move flaps, ailerons, flaperons, elevator, rudder, etc. Servos commonly used for a particular application are fine here if they can be fully recessed and firmly mounted in structure ahead of the hingeline.

Installation is made practical using the Item #500 RC Aircraft Servo Coupler listed at $6 in Accessories in the website http://www.kimbroughracingproducts.com. This can be ordered direct on line. Coupler parts (white) are on the black background. A pair is in the $6 package.



This exploded view shows how parts go together. An adapter slips inside the coupler bottom, seating to its internal flange. These fasten to the output gear with the servo screw. The top is secured with setscrews that also secure the drive shaft. Flats on shafts avoid slippage.



Top right is the coupler top that has a pilot hole to open for use with solid SS wire shafts measuring from 1/16" to 1/8" in diameter or comparable metric sizes. To enlarge the pilot hole in the coupler top, drill a ¼" hole through a board & wet the hole to swell it to grip it.

For a 1/16" shaft, open the hole with a #51 bit. For the most commonly used 3/32" shaft, use a #41 or #40 bit. Top left is the splined coupler bottom. It receives a double-splined adapter from the 5 adapter tree. One or the other fits the output gear of most popular servos. Setscrews secure the top inside the bottom & seat to flats ground on the shaft to lock it in place.

<u>The #500 package includes a pair of the molded parts shown, four setscrews & an Allen wrench</u>. Two pair are needed for a four servo wing. If an accessory "Adapter Sleeve" is listed it has an ID of .166". Use it in place of the coupler top to accept the .165 OD hypo tube that forms the largest section of torsionally stiffer drive shafts assembled from telescoping sections of stainless steel hypo tubing.

The 3/32" shaft works for most thermal ships except DLG's. An aileron application is depicted. Particularly note that the elbow of the bend is at the hingeline & that the pocket front edge is a little behind the hingeline. 1/16" works well in practice. Pockets have a top & bottom, spaced in parallel planes for a "slightly snug" fit with the shaft.

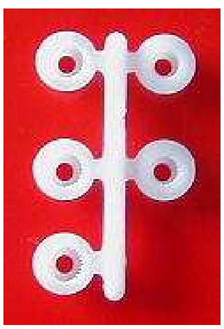
Pockets & shafts are easily fabricated from common materials as detailed further on. Such shafts & pockets are optionally available with Genie packages. A line of solid shafts, pockets & tempered aluminum coupler tops is commercially available from modeler-machinist Walt Dimick. See pg. 9.

With servo oriented 45 degrees to the hingeline, as shown above, deflection available either way is similar to the bend angle. This orientation & an 85 degree bend will provide full down flap. For ailerons, with the shaft bent no more than 45 degrees, the servo & shaft may be squared to the hingeline as illustrated with the shaft segment on the right in the drawing on page 4.

Smaller bend angles equate to moving a clevis closer in on an output arm. Example: Compared to 45 a 32 degree bend allows 30 degrees deflection while doubling effective servo power & resolution. Go to the link on page 9 for an in-depth engineering discussion of the RDS.

"Pockets" slip over the bent end of the drive shaft. Hinging stabilizes the shaft in the vertical. If hinges fail, the surface can slip off undamaged, unlike when tethered by a horn, clevis & pushrod. Unlike a pushrod, the rotary action doesn't impart forces at right angles to the axis of the output gear & so is much easier on servo gear trains & pin sockets in servo cases.

DOUBLE SPLINED ADAPTERS: Known to fit what is shown below. Fully press adapter into the coupler bottom. Some fit very tightly. Using the servo screw, seat the assembly on the output gear. If adapter flange binds against the servo case, thin it down with a sanding block.



LEFT TOP: Hitec 60/80/85/101, etc. Volz Alu-Star

LEFT CENTER: Std. Airtronics including 94761Z, JR, Multiplex, Sanwa.

LEFT BOTTOM: Std. Futaba, FMA series 300, Critter bits, some larger ACE, Dymond.

RIGHT TOP: Std. VOLZ, Airt. 557 (very tight). See bordered paragraph below about using this on the JR 168 & Hitec 125 thin wing servos.
RIGHT BOTTOM: FMA 88/90/95/100 etc. ACE 8112, Cirrus CS20/21, MPI MX 30.

To prepare the Volz adapter to go on the JR or Hitec thin wing servos, drill a 5/16" hole in a board. Seat adapter in it. Using a sharp 3/16" bit in a drill press, gently widen a little of the adapter opening. Square up the adapter & gently press it over the output gear with a bench vise.

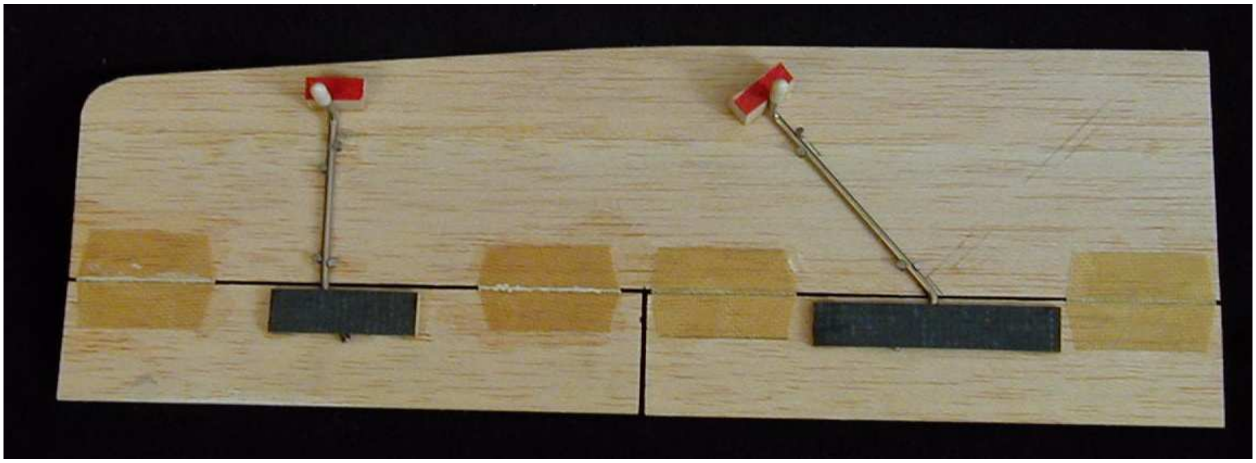
CUSTOM SPLINING: Any of the three standard adapters on the left can be fitted to a smaller output gear as follows: Plug the output gear screw hole with paste wax. Wax the gear & case or coat with PVA release agent. Put clear tape over the hole for the servo screw in the adapter. Almost fill the adapter with epoxy. Press it, visually centered, over the output gear. Let the epoxy cure well. Pry off the adapter. Clean off wax & excess epoxy. Open the servo screw hole.

The splined coupler bottom itself can be custom splined. From an adhesive backed paper, cut a disc to cover the screw hole at its bottom. With a pin, punch a hole in the center of the paper. Almost fill the splined bottom with epoxy. As closely as possible, center the bottom over the output gear. Run a waxed round toothpick into the pinhole & find the screw hole in the gear to finalize the centering. When cured, pull out the toothpick. Open the hole for the servo screw. For heavier duty applications a filled epoxy is recommended.

RDS KINEMATICS: During deflection, up to 3 motions simultaneously take place. (1) The bent section of the shaft works in a fan pattern within the pocket. (2) The pocket moves slightly fore & aft on the fixed shaft. (3) The shaft "floats" slightly up & down ahead of the hingeline if the geometrical plane of the hinging and that of the center line of the pocket opening are not coincident. (Hinge high, pocket low, etc.)

These motions enable the RDS to work properly. The motions take place simultaneously to avoid bind or pulling on hinges. Snug fitting tubes by the hinge line should not be used as they interfere with the "float". Lateral movement is to be restrained. Actually a snug tunnel in a denser foam core works fine. A hole in any ARF sub-spar allows the float and controls lateral movement. The pocket itself supports the bent end of the shaft.

The mockup illustrated below is worth making to help understand the RDS mechanics. Cut a piece of 1/16" x 4" x 12" "C-grain" hard balsa to make a panel with 1-1/4" wide flap and aileron. Along the flap hingeline, bevel both the wing and the flap to 45 degrees so the flap can drop 90 degrees down. Top hinge the surface as shown with anything you have in sight. Here I used some of the "Individual Kevlar Hinges" described in File 7. A tacky adhesive tape will do. Wick a little instant CA glue around the edges. The hinges should not be stiff. On the underside, glue some balsa strips forward from the hinges to stiffen the "wing".



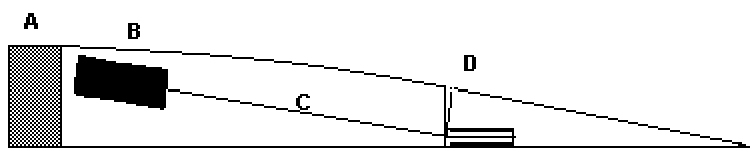
For the "drive shafts" get a piece of 3/32" wire that is easier to make low radius bends in than music wire. A wire coat hanger will do. Check out welding rods. Get a straight piece. Cut two pieces 4" long. Smooth the ends. For the aileron, bend 5/8" 30 degrees. More bend gives more deflection, but this will do. For the flap, bend 5/8" 90 degrees. Less will do, but 90 is easy. With those bends horizontal, make vertical bends as shown. Snip the upright ends to about 1".
Bends slip into "pockets" that have a top and a bottom in a real installation, equally spaced for a "slightly snug" fit to the shafts. Here I CA glued some ¾" sq. x 3/32" hard balsa pieces to ½" x 1-3/4" and 2-1/2" long "tops" to make "1/2"square "spacers" at the ends, then trimmed the excess.

Those black tops are .028" x ½" wide strips of carbon plate I had on hand. 1/16" ply will do for the mockup. Here, to keep it simple, I just used the flap and aileron to form the "bottom". See further along about making pockets with the slightly snug fit needed with the drive shaft. Note the pockets are placed a little behind the hingeline. This avoids jamming during deflection.

On the underside of the "wing", glue down some .25" to .375" thick pieces of wood, other than soft balsa, in which to drive some short brads used to stabilize the shafts sidewise. If you look carefully you'll see brads either side of the shafts near each end. This simulates a real installation.

In a real installation, it will be necessary to slide the drive shafts toward the TE to uncouple the "coupler' from the servo output gear. In the illustration for the aileron, it will slide straight back. In the flap situation, the opening is 1-1/2" wide to allow the shaft to be slipped back at an angle to clear the spacers.

The "Sweet Spot": By moving the shaft fore-aft, you'll find a spot where deflection is smooth and easy. The blocks marked red are to be located so that when the upright bend touches the block, the elbow of the bend is at the "sweet spot" Glue those blocks in place.



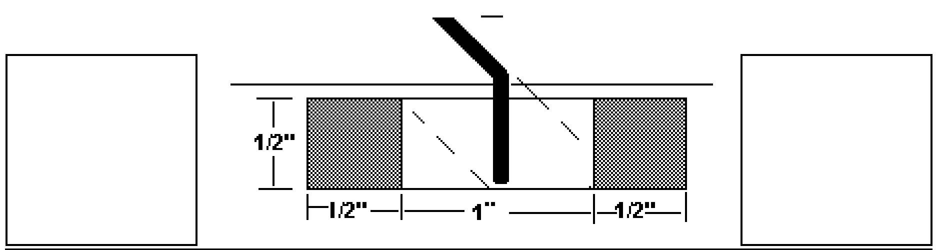
A servo may require tilting to direct the shaft into the pocket, as illustrated here. "A" represents the spar, "B" the servo, "C" the drive shaft & "D", a low mounted pocket as commonly used with flaps.

The intrinsic flex in the injection molded coupler allows directing the shaft into the pocket. Note what makes the RDS work well. The servo must be firmly mounted, possibly with a tilt, to (1) direct the shaft into the pocket & (2) keep the elbow in the "sweet" spot. (3) The pocket needs to be located a little behind the hingeline, say 1/16". (4) It needs to fit the shaft without bind or slop. (5) Lateral play needs to be controlled. Again, the intrinsic flex in the plastic coupler allows the "float" similarly as a universal joint does in an automotive drive train. This is independent of the torsional rigidity of the shaft.

SERVO ORIENTATION

If servo wells are angled as illustrated below installations are made easy. If you're making bagged wings, you can so angle the wells, but ARF squared up wells hamper angled drive shaft installations for flaps. As shown in the larger individual drawings, the front edges of the pockets go a little behind the hingeline. For flaps, elbow of the bend goes a little behind the hingeline & for ailerons, a little ahead. Actual elbow locations are manually found to be the "sweet" spots in a particular installation as the shafts are sized to length. See File 3 about that sizing.

The images below show "medium" pocket sizes for 3/32" shafts & typical elbow "sweet" spots.



MOUNTING SERVOS

The RDS requires easy attach/detach of servos & drive shafts during installation & after hinging. This is done by positioning a shaft in the pocket opening so the shaft itself it can be slid back into the pocket as illustrated by the dashed lines above. In the Genie line, File 3 details securing a servo with a "hat bracket" that screws to rails either side of the servo. Another way is to size the rails to almost come to the top of the case on its side and screws a thin plate over the servo.

To get 90 degrees down flap for precision landings, angle the servos at a convenient 45 degrees and make the bend in the shaft 85 degrees. Gap wipers or hinging may restrict such deflection.

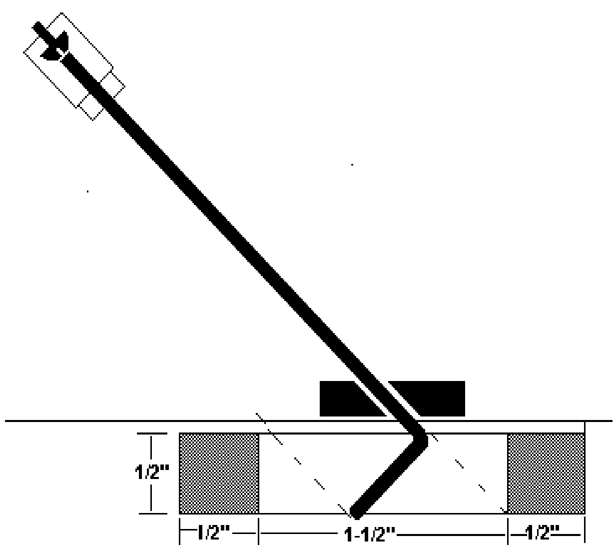
For ailerons, using the 45 deg. servo angle, a 45 bend angle allows more deflection than normally wanted. A 32 deg. bend allows 30 deg. deflection and doubles power and resolution. Aileron servos do not have to go in angled.

If existing wells will allow the installation, here is how to go about it, illustrated with an installation for flaps

The servo, not shown in the drawing, would be attached to the Kimbrough Coupler. A precise location for the mounted servo would have been determined. The shaft would be sized so when jammed to the servo screw (black), the elbow would be at the “sweet spot”. If a sub-spar is in the structure ahead of the hingeline, open a hole in it so the shaft can go in and “float” vertically, but restrain lateral movement. The pocket itself provides support for the rear end of the shaft. Pocket dimensions and planform shown will allow a shaft with a 5/8” long bent end to be installed.

Lacking a sub-spar, lateral movement can be controlled by blocks (black) between the skins. Wire shafts can be stiffened axially by bonding tubing on after sizing. Walt Dimick offers stiffer hardened and tempered solid shafts made from drill stock. If stiffer telescoping hypo tubing type shafts are desired, a ¼” sleeve with an ID of .166” can used in place of the Kimbrough coupler top to accept .165 hypo tubing. Walt Dimick can provide the sleeves. Drill for and run a 1/16”pin through the assembly to prevent unwanted rotation.

Follow the MECHANICS AND PROGRAMMING section in File 3. Study the section on sizing shafts to length. Position the coupler bottom with adapter on the servo so the opposing setscrews are properly oriented for easy access. Attach it with the servo screw. A longer screw may be needed. Finalize precise shaft length after the HEMS mount is attached and servo location set.



<u>INSTALLING SHAFTS</u>: (1) With the pocket for the drive shaft installed, make an opening for the shaft in any sub-spar ahead of the hingeline. (2) Manually lower the flap to run the bent shaft into the servo well and away from the hingeline. (3) Manually move the flap toward neutral so the bent end of the shaft can be backed into the pocket. (4) Coupler slipped on the servo, place servo in its mount and in the well. Run the shaft fully into the coupler. With the elbow correctly located by the hingeline, a flap can be manually dropped smoothly and easily. As needed, adjust shaft length to achieve that. (5) Grind the opposing flats as detailed on page 9 below. (6) Fully seat the setscrews. (7) If there is no sub-spar in which to make a hole, install the guide blocks, inboard one last. With servos mounted under the top skin and with flap pockets mounted on the bottom skin, the servos are naturally tilted to direct shafts into pockets. If more tilt is needed, it’s done with an epoxy putty mix between the HEMS base and skin.

In bagged wings, installation is easy if the modeler can locate, size and cut his own wells as detailed in File 3. Tunnels for leads to flap & aileron servos need to be located to enter the wells.

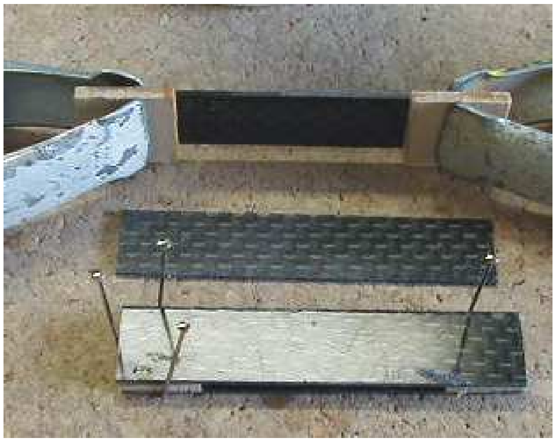
<u>SERVOS WITH SIDE MOUNTING LUGS</u>: if the well is sized to allow shifting, servos such as Volz, Hitec 125, JR 168, Airt. 761, etc. can be shifted by removing the mounting screws. To keep the well opening small, a recess could be made in the foam under the skin to allow ample shifting.

Telescoping SS tubing will be more torsionally stiff than solid wire. I do not deem the extra stiffness necessary for traditional thermal work. F3B and F3J are heavier duty applications.

MAKING SHAFTS FROM STAINLESS STEEL(SS) WELDING RODS: This is a “no brainer” requiring a bench vise & hammer. SS is smooth, reasonably uniform in diameter, takes a sharp 90 degree bend without cracking & doesn’t rust. Cut pieces long enough, typically 5”-6”. Round an end, Clamp 5/8” horizontally in a bench vise. To make needed low radius bends, pound near the jaws. Jaws do not mar areas that contact the pockets. Four shafts can quickly be made from the welding rod. Set aside for later sizing to length as detailed in File 3. After sizing, grind flats. See page 9 below.

MAKING SHAFTS STIFFER: after sizing a SS shaft to length to put the bend in the”sweet spot”, it can be stiffened by bonding a brass tube over it with CA glue. Size the tube to length to not interfere with insertion of the shaft into either the coupler or the pocket.

MAKING POCKETS; this is also a “no brainer”. Typical sizes for ailerons are shown below for 1/16”, 3/32” & 1/8” shafts. The “medium” for 3/32” shafts would be ½” x 2” with a 1” slot. For flaps, pockets need to be longer with a longer slot to allow the broad fan motion & to slide the shaft in & out of the coupler. Another ½” opening length usually works well. Clearance is needed behind a pocket to back the shaft out of the Kimbrough coupler to disengage it from a mounted servo. I’ve used only the medium size with 3/32” shafts for all my sailplanes from spans from 6 to 12 feet. Larger pockets & shafts would be appropriate for thicker surfaces or heavier duty applications.
Pocket tops/bottoms of smooth Formica, CD or CF plate spaced to make a slightly snug fit with the shafts, work very well. Carbon plate is most rigid. .028-.032 thickness works well. Carbon plate can be easily cut with a cut off wheel in a rotary tool. The picture shows how it can be mounted to make a 1”cut & shims used for ¾” & ½” cuts.



For 3/32” shafts, 3/32” bass sheet works well for spacers. Clamp ¾” sq. pieces to a top or bottom. Wick join with thin CA. Trim excess spacers. Clamp on the other piece. Check for “slightly snug” fit with shaft. If loose, a few, even swipes with the sanding block will get a fine fit.

Over cork board, etc., place four pins as shown as guides to position the other piece. Coat fingers with paste wax to avoid bonding them. Dab CA on inside ends, flip over & press in place. The pockets here were intended for flaps with shafts oriented at 45 degrees so they have a 1-1/2” opening.

It’s okay to bevel & thin the assembled pockets on a belt or disc sander to get them between the skins. Then wrap ends with Kevlar thread to prevent splitting. When pockets are joined to the skins all becomes very rigid. See File 3 for details about installing pockets. In 3 piece wings, aileron servos can go in the center section. See File 10 about installing hard slots in the ends of ailerons.

CAVEATS APPLICABLE TO ALL INSTALLATIONS

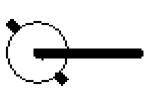
1. Use servos & drive shafts suited to the application. In high speed, heavier duty applications, favor larger shafts if there is space for the pockets between the skins.

2. Vertically position the pockets as close as practical to the plane of the hinges to prevent shafts from slipping out of a pocket in extreme deflection. This is not a concern in thin wings, but for example, if you had a top-hinged thick aileron & a low pocket, it could be.

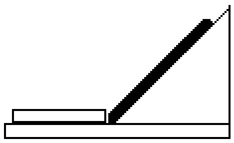
3. Where possible, keep shafts short by using thinner servos that can be mounted closer to the hinge line. Short shafts are less subject to axial flex. Axial flex may be a concern with high speed, heavy duty, and high load applications. In contrast, flex would be advantageous in combat foamies.

4. Until shafts have been sized to precise length, flats ground & programming done, there is no need to seat setscrews. When a screw hits the shaft, go easy as too much torque will strip or break the plastic couplers.

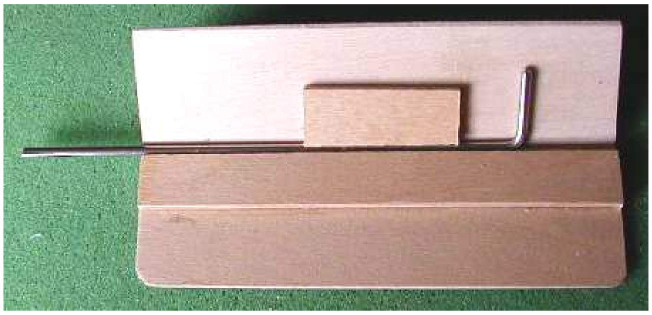
5. SETSCREW & FLATS ORIENTATION: After shaft length is finalized, opposing flats can be ground on the long end with a bench grinder. Flats must be located so setscrews are readily accessible through the servo well. The drawing below illustrates proper location. (Thanks, David Stack, for this 45 degree flats orientation suggestion.)



Think of this drawing as the rear view of the coupler for the right flap servo with the wing inverted. The heavy line represents the end of the shaft pointing inboard in neutral. The outboard setscrew is then accessible. Upon CCW rotation to down flap, the inboard screw becomes accessible. Flats on the shaft must face the setscrews. This requires a suitable holder for grinding. The next drawing shows its cross section.



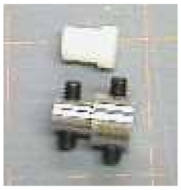
The heavy line represents the bent end of the drive shaft. Triangular stock is glued to a base of ply. A ply strip is glued to the base to keep the shaft in position. A flat is made by running the vertical edge of the grinder wheel on the long (horizontal) end of the shaft. A holder as pictured below with cleat glued at the center stabilizes the shaft during grinding. Moved against the wheel, vertical flats can be ground on the protruding end of the shaft. A holder 4" to 5" long will do fine.



A 2^{nd} & opposing flat is made by rotating the holder 180 degrees with the shaft left in its original position.

To get a RIGHT & LEFT set for both flaps & ailerons, point the long end of one shaft in the opposite direction to make the flats on it.

With opposing flats, the two setscrews can be seated through the stock plastic coupler top to secure the shafts for typical applications. Just don't overdo the torque & risk stripping threads.
For heavy duty, demanding applications, or where time is a premium, check out the fine RDS accessories by modeler-machinist Walt Dimick at http://www.irfmachineworks.com/rds.
The shafts, made from drill stock, have a long single flat, not oriented at 45 degrees as detailed above. They have a feel similar to Allen wrenches.



Walt's tempered aluminum coupler tops for heavier duty applications, used in place of the plastic ones, allow firm seating of four setscrews to shafts without danger of stripping.

If the fit between a shaft & pocket is good (slightly snug) but surface play is subsequently noted, one or more reasons may be found below.

1. There's slop in the servo gears. 2. The surface itself is flimsy or flexible. 3. The flat is convex. 4. Setscrews are not well seated. 5. The servo or its mount is loose. 6. The shaft used is too springy. 7. Hinging allows play between the fixed & moving surface. 8. The servo screw is not fully seated allowing the adapter to slip on the gear. 9. An adapter may seem to fit, but is the wrong one & allows slippage. 10. The pocket is wiggling around in the surface. 11. The pocket has split. 12. The shaft is not laterally restrained.

What I know about the RDS has been empirically determined. Technically oriented readers can go to http://www.hauninger.gmxhome.de/hobbies/modeling/RDS/RDS.html. Copy that link to the internet address line if it does not display from here. Use your pointer to slide the main screen to the right to access related graphs and formulas.