Mini Servos TEST REPORT

REX BOYER TESTS SEVEN MINI SERVOS

IN our first servo report published in the *May* 1978 issue of R.C.M.&E. we looked at 'standard' size servos and their relative performance. We were not surprised to find widely differing results from one servo to another, but were surprised to find differences in servos using the same motor/amplifier combinations.

This further report looks at the available mini servos and in one case super mini.

Eight servos were submitted by manufacturers, two of which used the same mechanics. Servos tested were the *Kraft KPS18*, the *OS CS50*, the *Sanwa SM 322*, *Sanwa SM SM 402*, *World Engines D&R Bantam*, *World Engines Dunham D5* and *Futaba FD 30M*.

Comparison of gear ratios in these servos was non-conclusive as all used different motors with different performance; however, comments are made on the mechanical details of the servos.

Technical Performance

The servos were mounted in our standard test rig as described in the first part of this feature, the loads applied were however lowered to give a more realistic output performance check. The results given are the average of several runs at each load and were taken with a "cold" amplifier. A 30min. cooling period was allowed after the performance figures were taken before the standard torque tests were taken.

As usual figures are calculated for a 75° total travel; the actual travel is also quoted.

We felt the travel of all the servos with the exception of the *World Engines* was extreme, for 1 — 1.5 — 2 millisecond timing pulse length. One can only assume the systems to which these servos are matched use less time change on their pulses; a point to be borne in mind as only the *O.S.* had a means of varying this travel.

The one servo whose performance we did not like was the *W. E. Bantam Midget*. The speed of response was quite the fastest we have yet seen but unfortunately the damping of the servo loop was abyssmal taking up to 2 full oscillating cycles to dampen out with up to 20% overshoot. Even against a load of 4oz/in it still took 2 cycles to quieten, and of course a lot of time, making the actual transit time 50% longer than that given in the table, it is felt that much more use could be made of this speed by increasing the gear ratio to give more torque making it much easier to dampen dynamically. It will be noted that the overshoot figures are given for this servo only as the other servos do not overshoot to any noticeable degree the columns are omitted.

Servo Details

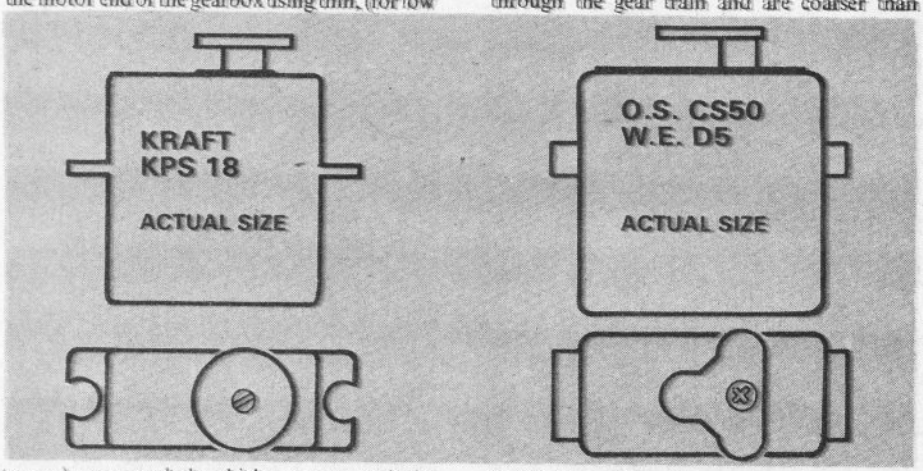
Kraft KPS 18

This servo, the smallest of those tested, in fact turned out to have one of the best overall performances. There is nothing about its construction or design which is at all startling or unique; the motor is a mere 10mm in diameter, carries the label "Made in Japan", so its origin is unknown. It utilises a tubular steel case instead of the more familiar spun aluminium case of conventional design.

Gearbox design shows detailed thought, with the motor end of the gearbox using thin, (for low torque) gears and the thickness progressively increasing to the output gear where the size of the teeth are increased. The gear train utilises six gears to accomplish the desired reduction culminating in a square drive for the output disc.

Examination of the amplifier reveals a *Signetics* NE644W I.C. sandwiched between two small P.C. boards, component sides inwards. Highly specialised components are used to get the necessary values in such a small space. The amplifier module measures a mere 14×9×9mm and is for three wire +ve pulse operation. The lead out wire is terminated in a standard four pin *Kraft* connector.

The three part case is held together by four screws passing through the top case to the bottom, sandwiching the gearbox section between. No limit stops are provided on the rotary output.



Kraft KPS 18

Load oz/ins	Against Load	With Load
N.L.	.289	.282
2	.435	.279
3	.476	.279
4	.558	.279
5	.624	.279
6	.903	.279

Just stalled load 7 oz/ins = 18.7 oz. at ⅜ radius
Travel = 58° — 56° TOTAL 1:14°

O.S. CS50 and World Engines D5

The description of these two servos from the mechanical sense is the same as both utilise the same mechanics; variations from the two will be given as they occur.

These two servos are in fact physically the middle size of the four types tested. The gearboxes again have graduated sizes of gear from thin to thick, the motor pinion is in this case of plastic, the teeth sizes remain the same right through the gear train and are coarser than *Kraft's* fine gears. The gearbox has a much coarser feel about it and sounds more noisy under load. It is felt that a better performance would have been achieved if at least the first gears in the train had been of finer teeth. The number of poles on the motor seemed to clash with the number of teeth on the motor pinion. This is always a problem with small D.C. motors as the torque/rotation is a series of highs and lows as the poles go past. This feature together with low numbers of pinion teeth (which incidentally should not be less than 12-14) give what is known as a POLIGINAL effect rather like running an old type threepenny bit along on its edge, which in turn gives a high/low ratio efficiency performance. It does not take much imagination therefore to realise that if the motor is at a low point on its torque cycle and the gear box is at a low efficiency point on it's cycle, then that equals low output.

Returning to the servo, the rest of the construction is well thought out, both ends of the gear spindle are retained when the top case is removed, and the gears would appear to be of a loaded plastic nature. They really are quite hard and under test showed no tendency to indentate as do some plastic gears.

We were a little disappointed in the motor location. A *Sagami* unit, incidentally of conventional spun aluminium construction some 12mm diameter, which is located on a shallow shoulder at the rear end. It was quite possible to assemble the servo with the motor askew causing loss of performance. In the *O.S.* version of this servo the motor had been bonded

to the lower gearbox plate thus eliminating the problem. Still we feel not all that clever.

In the *World Engines* version, a *CTC* cermet pot is used as a potential divider. In the *O.S.* a standard *CTC* cermet type is also used in the three wire mode.

Amplifier design in the case of *World Engines* used a 12 pin D.I.L. NE544 with various miniature discreet components to suit, the whole assembled on a single P.C. board in the conventional manner.

Turning to the O.S. amplifier we find an i.c. included which appears to be a *Signetics* NE644 as used in the KPS18 mounted edgewise in the centre of the P.C. board plus two output transistors packed tightly adjacent. A very small pre-set pot is fitted to the board for setting up procedures, the whole amplifier being liberally coated in a rubbery compound.

The servo case is in two parts held together by plastic clips. No provision is made for mounting making servo tape or special clips which are supplied with the servo, essential. Output is via a square drive to the output arm.

World Engines D5

Load oz/ins	Against Load	With Load
N.L.	.40	.378
2	.437	.378
3	.389 + .411	.367
4	.512 + .534	.356
5	.589 failed to reach command position	.356
6	Failed to reach command pos.	

Just stalled load 5.75 oz/ins = 15.35 ozs. at 3/8 radius
Travel + 44° — 40° TOTAL 84°

O.S. CS50

Load oz/ins	Against Load	With Load
N.L.	.24	.225
2	.287	.217
3	.341	.217
4	.419	.217
5	.511	.217
6	.434 + 2.63	.220

Just stalled load 10 oz/in = 26.7 oz. at 3/8 radius
Travel + 58° — 63° TOTAL 121°

Sanwa SM322

This servo is of the familiar *Sanwa* construction with four screws to hold the case top on. The gearbox is exposed by removal of the top case and features brass gears, with the exception of the actual output gear which is of plastic. The teeth on the metal gears are of a very fine nature and under test ran smoothly. Only four gears are used in the train compared with the six in the other two types, the necessary reduction being achieved by having greater reductions at each stage, made possible by the use of metal gears. (Smaller teeth can safely be used with metal gears).

The motor is of rectangular shape, purpose made for the servo. It is a five pole type of open construction; it is possible to see the ceramic magnets and the armature. The motor is physically bigger than the cylindrical types in the other servos and carries a 14-tooth pinion compared with the eight tooth types in the other two servos.

Unlike most servos the feedback pot is of 16mm diameter utilising a carbon wiper. This is considerably larger in size than the more common CTC type. We were disappointed to find it was not of a moulded type.

Examination of the amplifier reveals a custom made I.C. bearing the serial number BA690, all the connections come out of one side, allowing edge mounting in a similar way to the *O.S.* amplifier, but without the problem of bending the top connections down one side. Two output transistors are used and some connections made to the top of components. The physical layout of this amplifier did not rate as the best in our opinion.

Performance wise, however, it showed considerable merit.

Motor and amplifier assembly are removeable from the servo by the opening of the familiar *Sanwa* hinged bottom lid leaving the gearbox fully assembled still in the case. Inspection and manufacturing code stickers were attached to this bottom lid which must indicate some form of quality control during manufacture; the first we have seen in servos. The output was the usual *Sanwa* parallel serated drive.

Sanwa SM 322

Load	Oz/ins	Against Load	With Load
N.L.	.37		.315
2	.411		.315
3	.437		.298
4	.455		.289
5	.508		.306
6	.63		.298

Just Stalled load 9 oz/in = 24oz. at 3/8 radius
Servo travel +53° — 54° TOTAL 107°

Sanwa SM402

This servo is the smallest unit we have seen from *Sanwa* and is the first to employ conventional construction techniques, the top and bottom case being held together by four screws through the bottom, sandwiching the centre case between them. The functional parts are all held on the centre case.

The amplifier contains the usual custom made *Sanwa* flat I.C. but an important addition is a thick film I.C. which appears to contain two output transistors. Nearly all the discrete components on the P.C. board are of normal size and whilst the components are quite close together they are not cramped.

The feedback pot appears to be the track part of a normal pot, which the servo case has been moulded to accept. Again we were disappointed to find it uses a sprayed paper type, but on the plus side it does use a carbon brush wiper assembly. The pot is connected directly to the output gear. All well thought out and easy to service.

The motor make is not identified but it is a 12mm diameter unit with a stainless steel case. One point which we did notice was that the motor armature is mounted on *ball races*, the first time we have seen this feature.

Turning to the gear box we find what can only be described as watch making on a large scale; all the gears are of steel/brass with a fine D.P. Only the output gear is of plastic and the D.P. on this quite large. The output gear is ball race supported at the output drive end, which is of the familiar *Sanwa* serrated type.

Without a doubt this is the finest set of servo mechanics we have seen, the benefits of this design constantly show up in the performance figures. As would be suspected the servo is a 3 wire unit with a +ve pulse input.

Mountings for the servo are the now familiar *Sanwa* captive grommets with metal eyelet centres.

Sanwa SM402

Load	Against Load	With Load
N.L.	.367	.332
2	.402	.315
3	.416	.315
4	.437	.315
5	.448	.310
6	.455	.306

Just stalled load 21 oz/in or 56 oz/ins at 3/8 radius
Travel + 52° — 53° TOTAL 101°

W.E. Bantam Midget

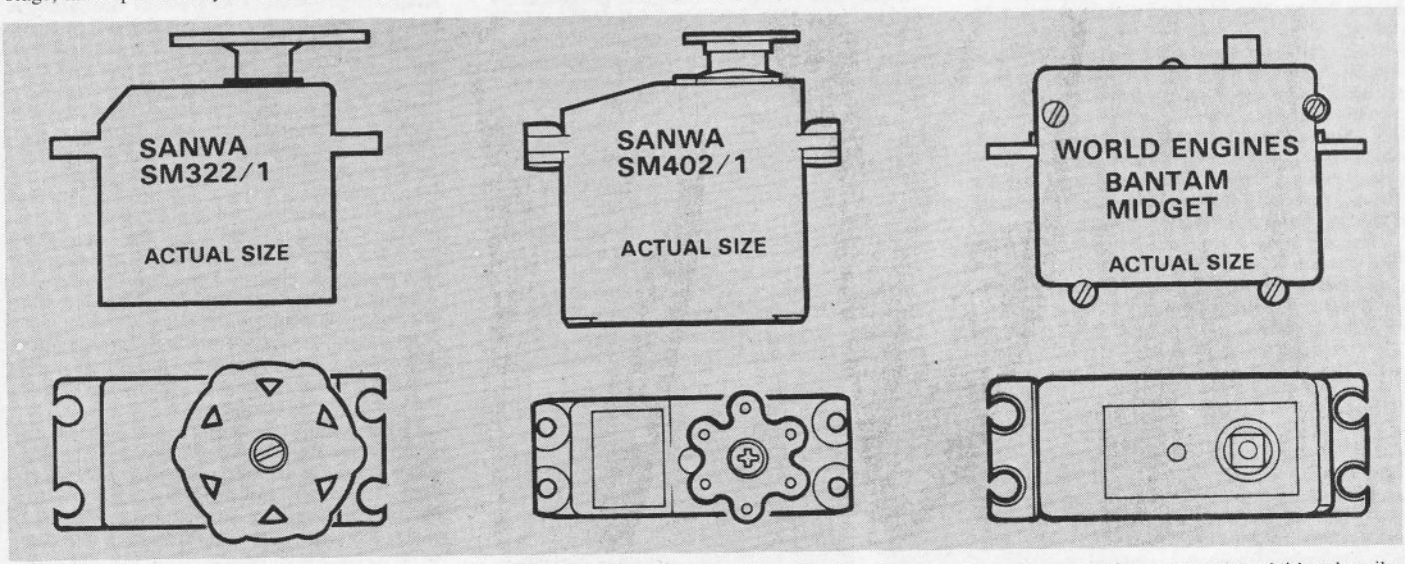
The second *World Engines* servo covered by these tests is the *D&R Bantam Midget*. The *DR* unit is of "different" construction to most other currently available units, not dissimilar from the S3 servo, offered in the days of the original R.C.M.&E. Digital System, but of about half the size. The *Midget* is offered with an all plastic gear train with teeth of rather course D.P. for so small a unit. The output gear is supported on the pot spindle at one end and on a plain plastic to plastic bearing (the case top) at the other. The gear tooth size does not vary throughout the train, but the output gear and its drive pinion are approximately four times wider than the other gears. Output drive is via a 4.5mm square drive. Limit stops are moulded troughs in the top face of the gear keying with a peg in the case.

Again we find the TOKO Micro motor in this servo and we were pleased to see a substantial C.T.C. type moulded feedback pot.

The servo amplifier consists of a *Signetics* NE544N. I.C. of standard 12 pin D.I.L. construction, and the P.C. board also carries 2 BC328 output transistors. This would appear to be an afterthought as the P.C. has been "modified" to accept them one side.

On examination we felt that some of the crossing over component leads ought to have been sleeved as they are not too rigid and easily move. It is only the bulk of the wires connecting the board to the motor and feedback pot that prevents some of the components from touching the feedback pot and it is felt a small piece of insulating material would prevent this from happening.

The case mouldings were nicely made but



could have been 1mm deeper so as to make it less difficult to get the motor leads in without flattening them. The case is held together with screws through the thickness of the unit. The servo is 3 wire for +ve pulse operation.

W.E. B.M.

Load Oz/Ins	Overshoot%	Against Load
N.L.	11	.19
2	9	.20
3	8	.21
4	6	.23
5	6	.25
6	5	.28

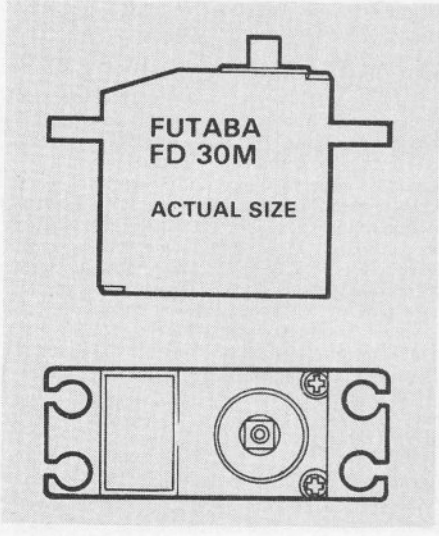
Just stalled 8 oz/ins or 21 oz/ins at 3/8" radius.
Travel — 45° + 44° TOTAL 89°

Load Oz/ins	Overshoot%	With Load
N.L.	11	.17
2	12	.15
3	13	.15
4	16	.16
5	18	.17
6	19	.18

Futaba FD30M

In common with the other big names in R/C, *Futaba* are offering a miniature servo in their current series. The FD30M is comparable in size with the *Sanwa* SM402.

Examination of the gear box reveals a combination of metal and plastic gears, the motor having an 8-tooth metal gear of fine diametrical pitch meshing with a plastic second gear, the output pinion of which meshes with



two more pairs of metal gears finishing with a very substantial output pinion. The output gear itself is of plastic of which a half of the diameter is used. The other half is of about 1/4 tooth height and forms a radial limit stop which engages with a peg in the top case.

This output gear is supported on the feedback pot at one end and by a ball race in the top case at the other with an integral 4mm square section output drive.

By removing two small PK screws the feedback pot is released to reveal a plated metal wiper and a sprayed paper pot track.

Motive power for the servo is provided by a 14mm *Toko* Micro Motor, a unit which is becoming very popular in current mini servos.

A 15mm × 14mm P.C. board carries all the servo amplifier components including a custom built IC marked BA801 which is mounted edge-wise with all 12 connections coming out of one side re-shaped to make it possible to fit them into a P.C. board. The P.C. board is of double sided construction, this being about the only way of getting enough lands onto the small size board. The usual number of discrete components are used with a physically small, main smoothing capacitor. The amplifier is, as would be suspected, for 3 wire operation, +ve pulse. Whilst small in size the amplifier does not need to be "shoe-horned" into the case and is easy to assemble. The case is of very robust construction for a mini servo with interlocking sections for added rigidity. All in all a well thought out design and of excellent quality mouldings.

Futaba FD30M

Load Oz/Ins	With Load	Against Load
N.L.	.370	.392
2	.346	.431
3	.341	.452
4	.333	.484
5	.323	.517
6	.323	.560

Just stalled 12 oz/ins at 3/8" Ra. Travel. -41 +46 TOTAL 87°

Analysis of Results

From the analysis of the results it would appear that the *Futaba 30M* offers the best load speed performance with the *OS* coming a close second. The response traces show that of the *World Engines* (Dunham) servo pulls out of saturation at high loads and there is just a hint that the *OS* is about to. Maximum pull is without doubt the forte of the *Sanwa S402*, even at the fantastic load (for its size) of 21oz/ins there is no sign of non-linarity or pulling out of saturation. Quite a remarkable performance for such a small unit, if only it were a bit faster!

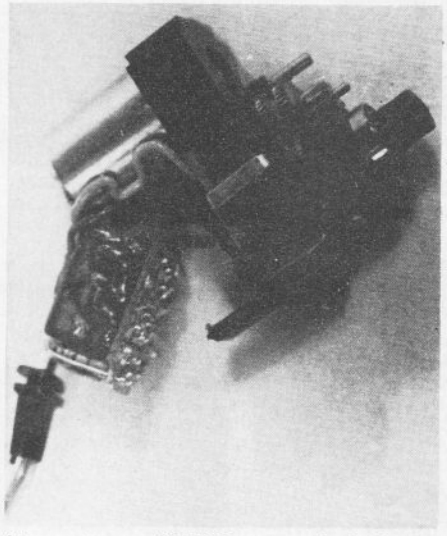
The *Kraft* is just getting near its stalled torque at 6ozs/ins so it does not really show up in the combined results.

What a pity the *W.E. Bantam Midget* is so grossly under damped as its speed is quite fantastic. Its output is average, possibly with some develpment it could become a winner.

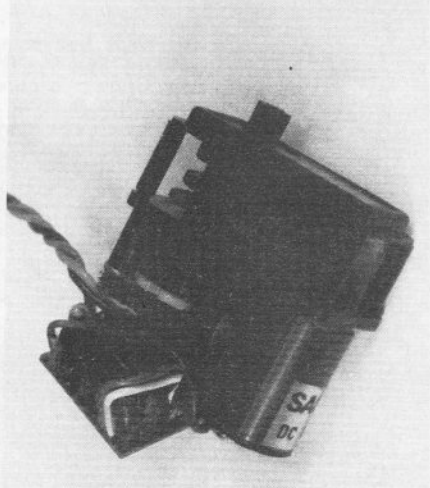
For sheer performance the *Sanwa 402* must be the tops. Its linearity over the full torque range (even up to stalled torque) is really good. It is really well made and has obviously been fully developed. We must also mention the *Kraft* as its mini size makes it a good runner up.

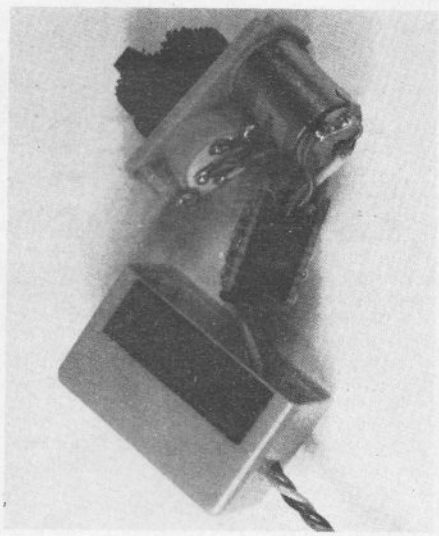
	Max Tested Torque	6 oz/ins Speed	N/L Speed
OS CS50	10	.34+	.24
WE (Dunham) D5	5.75	/	.4
WE (Bantam Midget)	8	.28*	.19*
Sanwa S322	9	.63	.37
Sanwa S402	21	.455	.367
KPS18	7	.903	.289
Futaba 30M	12	.560	.370

*Not including overshoot



Above: Sanwa SM402 — note the ballrace mounted output shaft and the metal gears. The thin film IC is mounted edgewise on the amplifier PCB. Below: OS CS50 servo — the same mechanics are used for the World Engines D5. W.E. guarantee the geartrain for life!





Above: Kraft KPS 18 — the amplifier components are ingeniously mounted between the two PCBs. Below: Futaba FD 30M-ballraced output shaft and a combination of metal and plastic gears are used. Note the diagonally mounted IC on the amplifier PCB.