Starlet 50

Model helicopter

Order No. 4445 Kit

Order No. 4446 Complete kit including motor and silencer

Warning!

The contents of this kit can be assembled to produce a working model which is by no means a harmless plaything. It is a complex flying machine, and if built incorrectly or handled incompetently or carelessly it can cause serious injury to persons and damage to property.
You alone are responsible for completing the model correctly and operating it safely. Please be sure to read the sheets SHW3 and SHW7 which are supplied in the kit. They include much important safety information, and represent an essential part of these instructions.

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We reserve the right to introduce modifications

Foreword

The STARLET 50 is a model helicopter of open-frame construction for .50-size engines, based on the proven UNI-Expert mechanics. The model is of considerable interest to the beginner as a robust and affordable trainer with unlimited scope for upgrading, but at the same time it will also suit the more advanced heli flyer with aerobatic ambitions, who is looking for a compact model with plenty of power reserves. The motor is started from above through the air intake for the cooling system. The silencer you use depends to a large extent on your individual requirements: a tuned pipe silencer is one choice, but the model can also accommodate a low-cost standard silencer and even a super-silencer, and since the recommended motor provides a generous excess of power this is a perfectly valid option.

With its large-diameter tail rotor the helicopter boasts an excellent tail rotor response, and the tail rotor continues to be driven in auto-rotations. The high chassis together with the curved tail boom provides plenty of tail rotor ground clearance; the tail rotor shaft runs through the boom in a curve and therefore cannot run out of true.

For the beginner the STARLET 50 represents a future-proof investment, as it can be upgraded directly to UNI-EXPERT mechanics or UNI-mechanics 2000 status; the mechanics can even be installed directly in many fuselage kits with the existing motor, i.e. without requiring an upgrade to a .60 engine. The STARLET 50 therefore forms an ideal starting point for a helicopter system which extends from a small beginner's machine to a model suitable for the expert or scale modeller.

The lightweight vacuum-moulded cabin fairing which surrounds the mechanics includes an integral cooling air duct, and is mounted on rubber grommets to provide insulation from vibration; the fairing can also be fitted and removed very easily, providing complete access to the radio control system components and mechanics. The fueltank is mounted in the cabin in a clearly visible location, level with the carburettor, so you can easily check the fuel supply with the model in the air. The long black eloxided tail boom is supported rigidly by two braces, and can easily be replaced in just a few minutes if it should be damaged. It is long enough to provide real flexibility: the beginner can learn to fly using short, low-cost wooden rotor blades with a reflex section, while the expert can install longer symmetrical-section GRP blades for unlimited „3-D" aerobatics.

Specification

Length excl. rotor approx.	1310 mm
Width excl. rotor approx.	240 mm
Height approx.	430 mm
Rotor Ø range	1160 ... 1365 mm
All-up weight min. approx.	3300 g

Warnings

- **The contents of this kit can be assembled to produce a working model helicopter, but the model is by no means a harmless plaything. If built incorrectly or handled incompetently or carelessly it can cause serious injury to persons and damage to property.**
- **When the model helicopter's engine is running, the two rotors are spinning at high speed and contain an enormous quantity of rotational energy. Anything and everything that gets into the rotational plane of the rotors is either damaged or destroyed - and that includes parts of your body. Please take extreme care at all times with this machine.**
- **If any object obstructs the rotational plane of the revolving rotors, the rotor blades will probably be severely damaged as well as the object. Broken parts may fly off and cause enormous imbalance; the whole helicopter then falls into sympathetic vibration, you lose control and have no way of predicting what the model will do next.**
- **You may also lose control if a problem arises in the radio control system, perhaps as a result of outside interference, component failure or flat or faulty batteries, but in any case the result is the same: the model helicopter's response is entirely unpredictable. Without prior warning it may move off in any direction.**
- **Helicopters have many parts which are naturally subject to wear, including gearbox components, motor, ball-links etc., and as a result it is absolutely essential to check and maintain the model regularly. It is standard practice with full-size aircraft to give the machine a thorough „pre-flight check" before every flight, and this is equally important with your model helicopter. Constant checking gives you the opportunity to detect and correct any faults which may develop before they are serious enough to cause a crash.**
- **The kit also includes two further information sheets - SHW 3 and SHW 7 - which include safety notes and warnings. Please be sure to read them and keep to our recommendations. They are an essential part of these instructions.**
- **This helicopter is designed to be constructed and operated by adults, although young people of 16 years or more may do so under the instruction and supervision of competent adults.**
- **The model features sharp points and edges which may cause injury.**
- **Flying model aircraft is subject to certain legal restrictions, and these must be observed at all times. For example, you must take out third part insurance, you must obtain permission to use your intended flying site, and you may have to obtain a licence to use your radio control system (varies from country to country).**
- **It is important to transport your model helicopter (e.g. to the flying site) in such a way that there is no danger of damaging the machine. Particularly vulnerable areas are the rotor head linkages and the tail rotor generally.**

- **Controlling a model helicopter successfully is not easy; you will need persistence and determination to learn the skills, and good hand-eye co-ordination is a pre-condition.**
- **Before you attempt to fly the model you should study the subject of helicopters in depth, so that you have a basic understanding of how these machines work. Read everything you can on the theory of helicopters, and spend as much time as you can watching other model helicopter pilots flying. Talk to chopper pilots, ask their advice, and enrol at a specialist model flying school if you need to. Many model shops will also be prepared to help you.**
- **Please be sure to read right through these instructions before you start work on the model. It is important that you clearly understand each individual stage of assembly and the correct sequence of events before you begin construction.**
- **Don’t make modifications to the model’s construction by using parts other than those specifically recommended, unless you are certain of the quality and suitability of these other parts for the task.**
- **We have made every effort to point out to you the dangers inherent in operating this model helicopter. Since neither we, the manufacturer, nor the model shop that sold you the kit have any influence on the way you build and operate your model, we are obliged to disclaim any liability in connection with it.**

Liability exclusion / Compensation

As manufacturers, we at GRAUPNER are not in a position to influence the way you assemble your model, nor how you install, operate and maintain the radio control system components. For this reason we are obliged to deny all liability for loss, damage or costs which are incurred due to the incompetent or incorrect use and operation of our products, or which are connected with such operation in any way.
Unless otherwise prescribed by binding law, the obligation of the GRAUPNER company to pay compensation, regardless of the legal argument employed, is limited to the invoice value of that quantity of GRAUPNER products which was immediately and directly involved in the event which caused the damage. This does not apply if GRAUPNER is found to be subject to unlimited liability according to binding legal regulation due to deliberate or gross negligence.

Contents

The instructions

We have invested considerable effort in producing these instructions, with the aim of ensuring that your model helicopter will fly reliably and safely.
Please take the trouble to follow the instructions step by step, exactly as described, as this is your guarantee of success. This applies to you whether you are a relative beginner or an experienced expert.

- The mechanics have to be assembled as shown in the drawings. Explanatory texts are provided.

- All the joints marked with this symbol  need to be secured with thread-lock fluid, e.g. Order No. 952, or bearing retainer fluid, Order No. 951. Remove all traces of grease from the joint surfaces before applying the fluid.

- All bearings, whether plain, ballrace or needle roller, must be lubricated thoroughly. The same applies to all ball-links and gears, even if the instructions do not state this specifically.

- You will find parts lists, replacement parts lists and the associated exploded drawings at the end of this instruction manual.

Accessories

Recommended motors and accessories for the Starlet 50

Motor	Capacity cc	Order No.	Expansion silencer	Exhaust manifold	(Tuned pipe) silencer
OS MAX 46 FX-HG	7,45	1893	1809.33 1871.72	2259	1783A or 2272
OS MAX 50 SX-HG	8,17	1921	1809.33 1871.72	2259	1783A or 2272

Glowplug battery, e.g.
Varta RSH 4 Order No. 1353
Varta RSH 7 Order No. 1352
2 V glowplug battery Order No. 3694 (Use only with resistor,
2 V glowplug battery Order No. 771 Order No.1685 or 1694.)

Fuel
TITAN S 12 Order No. 2612
AeroSynth COMPETITION SX-10 Order No. 2811

Starter
Electric starter, Order No. 1628 or 1626
12 V starter battery, Order No. 2592 or 2593.

Suitable main rotor blades

Order No. 1291.1	Wood, reflex,	500 mm long	Rotor Ø 1157 mm (supplied)
Order No. 1296	GRP, reflex,	552 mm long	Rotor Ø 1261 mm
Order No. 1269	GRP, symm.,	552 mm long	Rotor Ø 1261 mm
Order No. 1271	GRP, symm.,	602 mm long	Rotor Ø 1361 mm

Radio control equipment: see main Graupner catalogue
We recommend that you use a radio control system equipped with special helicopter functions, or a micro-computer radio control system such as the mc-12, mc-14, mc-15, mc-19, mc-22, mc-24.
As a minimum your RC system must include a 3-point swashplate mixer and the ability to control five servos for the functions pitch-axis, roll, collective pitch, tail rotor and throttle.

Servos:
Use only high-performance **servos** such as the C 4041, Order No. 3916, or other servos of equal or better quality.

Gyrosystem:
Gyro-System PIEZO 5000, Order No. 5146 with Super-Servo DS-8700G, Order No. 5156 or Gyro-System PIEZO 550, Order No. 5147 or Gyro-System G490T, Order No. 5137

Electronic speed governor:
mc-HELI-CONTROL, Order No. 3286

Receiver power supply:
For safety reasons we recommend that you install a battery with a capacity of at least 1800 mAh, and a switch harness designed to cope with heavy currents, i.e. with heavy-duty cables. We recommend the “Power switch harness“ with charge socket, Order No. 3050, in conjunction with the 4RC-3000 MH receiver battery, Order No. 2568

On no account use a receiver battery with more than four cells.

You can monitor the state of your battery voltage constantly by using the NC battery controller, Order No. 3138.

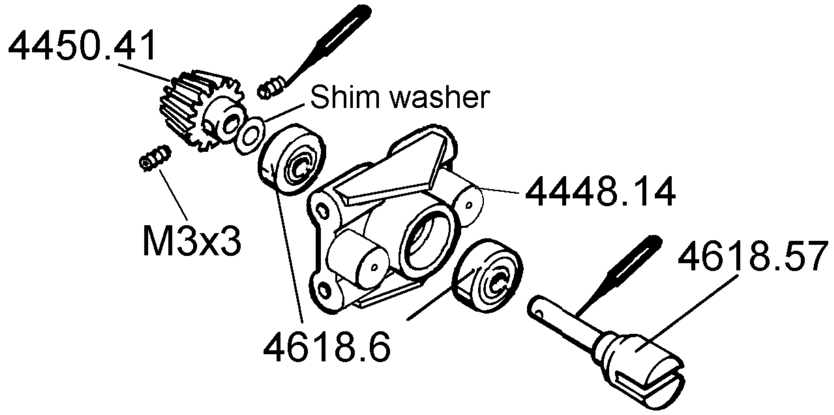
1. Assembling the main mechanics

The mechanical system of the STARLET 50 is based primarily on parts moulded in glass-fibre reinforced nylon, a material which offers significant advantages for use in model helicopters compared with aluminium, including high mass constancy combined with light weight, freedom from fatigue effects, low noise, and the ability to absorb vibration generated by the motor. The design of this type of mechanical system imparts a generous degree of robustness and rigidity; in a „hard landing" the ideal situation is that the parts either survive undamaged (and can therefore be re-used immediately) or alternatively fail completely, in which case there is no doubt about whether they have to be replaced. Aluminium chassis components tend to bend or become distorted, and this kind of subtle damage may not even be noticed; however, in the long term it causes damage to other components, has a negative effect on the model's flying characteristics, and can even have a serious effect on the safety of the whole system. The type of construction used in the Starlet 50 is simply not subject to this kind of damage.
Glass-filled nylon components therefore have many advantages, and the only drawbacks are their greater complexity, and therefore higher cost of manufacture, and the requirement they place on the builder to assemble and adjust the parts with greater care and a conscientious approach; you may also find that some parts need to be trimmed slightly in order to obtain a perfect fit. Provided that you invest a little extra care in constructing your machine, you will be rewarded by a model in which rates of wear are low, and which lasts much longer than conventional model helicopters.

Shafts, bearings, fits

Virtually all the rotating parts of the mechanics are ballraced. Wherever ballraces are used, it is very important that the shaft is a tight fit in the inner ring of the bearing. This ensures that it cannot rotate inside the ring; if this happens, the inner ring heats up (causing a blu-ish or yellow-ish discoloration), and the bearing is damaged and becomes unserviceable. In the worst case the bearing can become so hot that it melts the nylon bearing seat, and this destroys the correct location of the shaft relative to other components. Please note that this kind of damage is simply a result of an incorrectly fitted bearing, and is not an indication that the bearing support material is not up to the job.
A loosely fitted bearing can also cause another problem: the shaft starts to move axially inside the inner bearing ring, and the shaft wears in that area and its diameter is reduced. If there are gears mounted on that shaft, they now lose their correct meshing clearance, leading in turn to increased rates of wear, and eventual failure of the parts.
In order to prevent the problems described above, the fits between shafts and ballraces in the Graupner/Heim system are maintained on the „close" side of normal, and now and then this can result in too tight a fit if manufacturing tolerances accumulate in the same direction. This manifests itself in a bearing which cannot be fitted onto the corresponding shaft. If this should happen, just reduce the diameter of the shaft slightly by rubbing it down using fine wet-and-dry paper (600 - 1200 grit), until the bearing can be pushed into place using no more than moderate force. If manufacturing tolerances accumulate in the other direction, i.e. the fit is uncomfortably free or too loose, the solution is to fix the bearing to the shaft using LOCTITE 603 bearing retainer fluid, which guarantees a firm seating. If you use this fluid, please note that its cure time varies according to the fit; the closer the fit, the faster the cure. Under certain circumstances you may have only a few seconds to locate the bearing correctly on the shaft before it is fixed permanently.
If a shaft is supported in two or more bearings, it is important to ensure that the location of the bearings does not place axial stress on them. There are two ways of achieving this: you can either take the trouble to position the two bearings really accurately on the shaft, or use a combination of a fixed and sliding fit: one bearing is pressed or glued to the shaft to locate it permanently, the other is left as a sliding fit, i.e. it can be moved axially along the shaft using moderate force; in this case the second bearing will find its own optimum position once the system has been installed.
In general terms you can assume that the danger of bearings slipping on the shaft varies with shaft diameter and rotational speed: the smaller the shaft, and the higher the speed, the greater the danger.
The danger of stress in multiple bearings is greater when the difference between the internal and external diameters of the bearings is small.
If you are aiming to achieve maximum possible operational security and reliability, all these factors have to be considered in each individual case. The building instructions for the Starlet 50 state which connections should be made using thread-lock fluid and/or bearing retainer fluid.

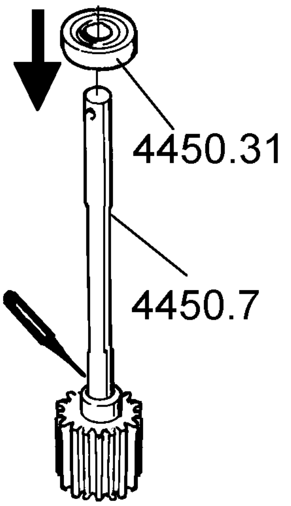
1.1 Assembling the tail rotor drive system *(bag UM-1A)*

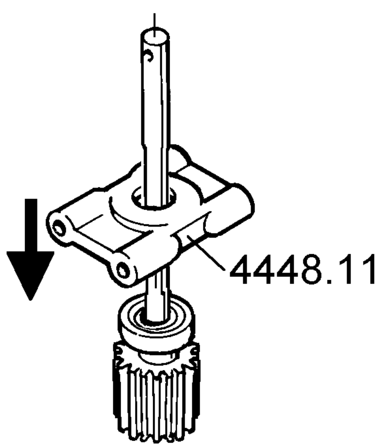


Please note that there must be no axial play at all in the quick-release coupling shaft 4618.57 when fitted in the bearings 4618.6. If the shaft does not seat securely enough in the bearings, fix it to the bearings using bearing retainer fluid 603, Order No. 951. This is the procedure: first fit the rear bearing on the shaft and secure it with a drop of bearing retainer fluid 603, and position it so that it rests against the coupling yoke. Wait until the adhesive has cured; this may take anything from 20 seconds to 30 minutes, depending on the closeness of the fit. Press this assembly into the bearing holder 4448.14 as far as it will go, then slide the front bearing onto the shaft, together with a drop of bearing retainer fluid 603. Slide the bearing straight into the correct position, and press it into the bearing holder as far as it will go. Now - before the adhesive sets - check that the shaft is still free-moving; it is important that the bearings should not be stiff; this is usually due to excessive axial stress. If this happens, tap lightly on the end of the shaft in the axial direction, using a screwdriver handle or similar, or tap harder on the bearing support, until the bearings ease into the correct position and the shaft turns freely. Now allow the bearing retainer fluid to cure fully.
Fit a shim washer and the pinion 4450.41 on the front end of the shaft, press it against the front bearing and secure the pinion in this position using two grubscrews: first apply a drop of threadlock fluid (Order No. 952) to the threaded hole and fit the first grubscrew, taking care to position the pinion so that the screw engages on the flat machined in the shaft. Rotate the pinion to and fro on the shaft so that the grubscrew takes up the optimum position, then tighten it moderately. Now screw in the opposed grubscrew and tighten it very firmly before finally tightening the first grubscrew permanently. This procedure ensures that the pinion runs really true on the shaft.

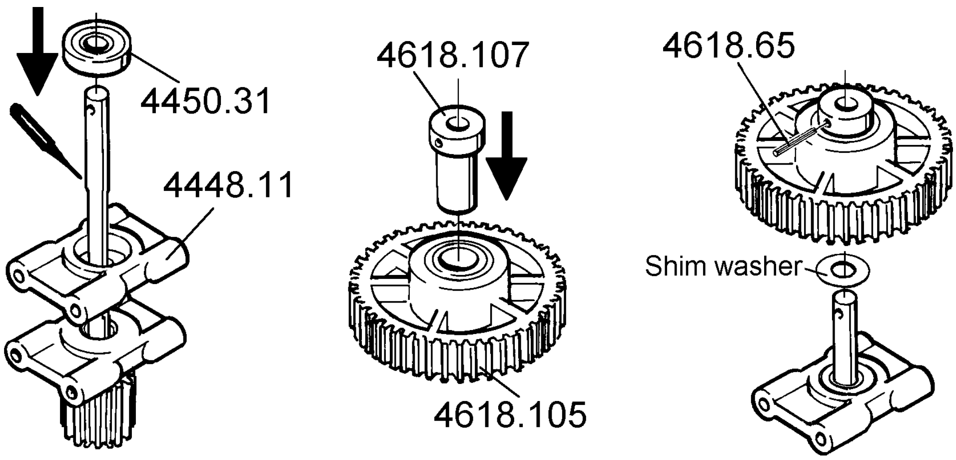
1.2 Assembling the layshaft *(bag UM-1B)*

Fix the bottom bearing 4450.31 for the layshaft 4450.7 on the shaft, using bearing retainer fluid 603, Order No. 951. Position the bearing resting against the pinion, then leave the fluid to cure. Press the shaft and bearing into the bottom bearing support 4448.11.

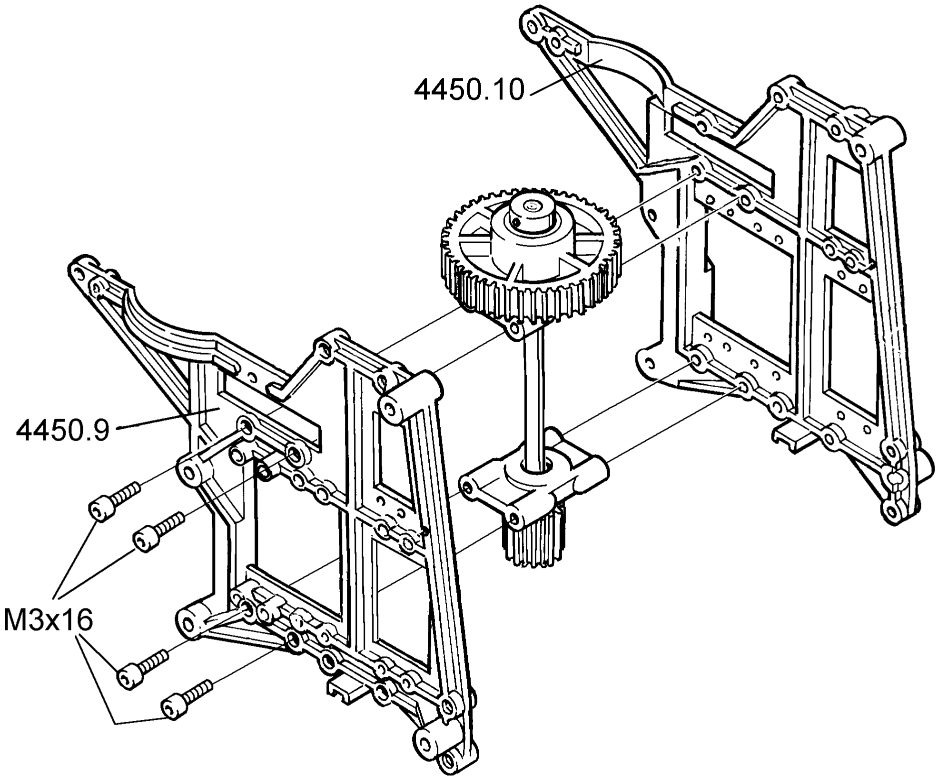




Fit the top bearing support on the shaft loosely for the moment (note the correct orientation; the opening in this bearing support should face up), then fit the top bearing 4450.31, followed by a shim washer. Press the freewheel sleeve 4618.107 into the gear 4618.105, and fit this assembly on the shaft. Line up the cross-holes in the shaft and the freewheel sleeve and carefully press the roll-pin 4618.65 into the holes, but only to the point where it projects a little way into the shaft; it must be possible to pull it out again at this stage.



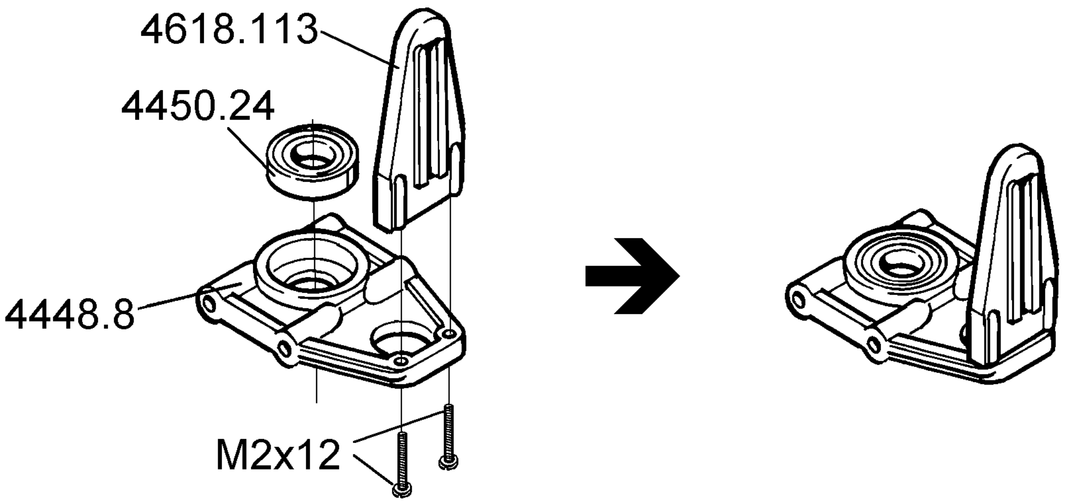
Now press the top bearing 4450.31 into the bearing support 4448.11 and push this assembly up against the shim washer under the freewheel sleeve. Take the layshaft assembly which you have assembled to this stage, and place it between the mechanics side frames 4450.9 and 4450.10, so that you can check that the top bearing rests against the freewheel sleeve above the shim washer when the parts are assembled. You may find that there is a gap, which has to be corrected by fitting additional shim washers. Take care not to fit too many shim washers, as this would place the bearings under stress.

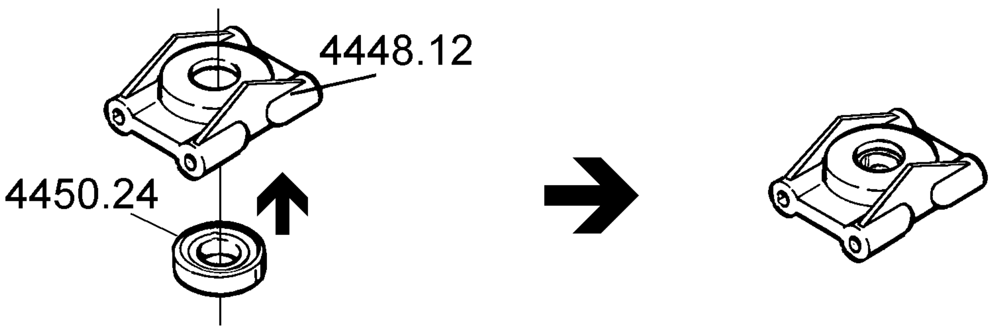


Once you are confident that the spacing is set correctly, glue the shaft to the bearing in the usual way using bearing retainer fluid, Order No. 951, but only after you have pressed the roll-pin into the freewheel sleeve fully and permanently. Fit this assembly between the mechanics side frames and tighten the screws fully before the bearing retainer fluid has cured, so that you can check that the shaft spins freely in its bearings. If it is slightly stiff, tap on the ends of the shaft to seat the bearings and eliminate the problem.

1.3 Preparing the main rotor shaft and bearings *(bag UM-1C)*

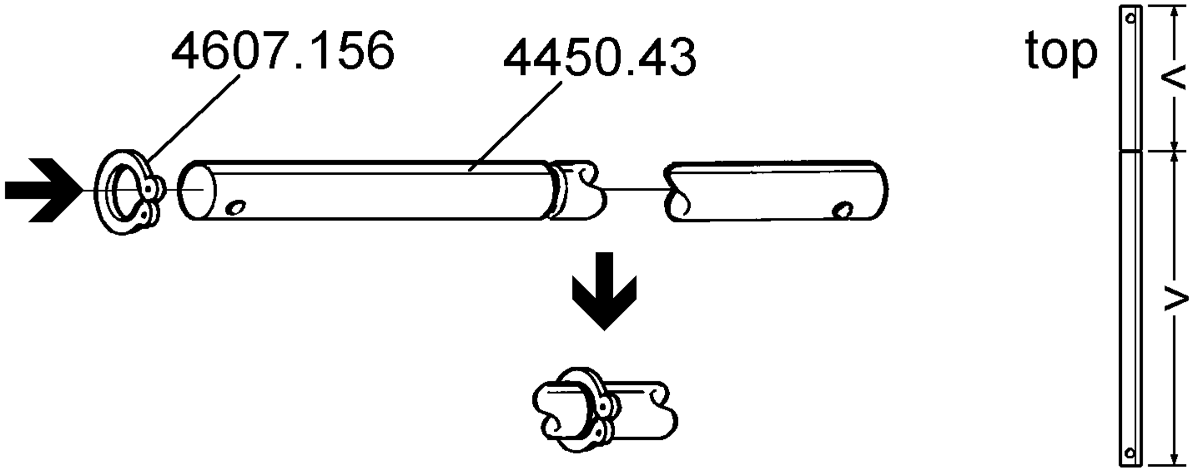
Fix the swashplate guide 4618.113 to the dome bearing holder 4448.8 using two M2 x 12 cheesehead screws. Press one of the ballraces 4450.24 into the dome bearing holder, and one into the main rotor shaft bearing holder 4448.12; grease both bearings.





The next step is to slide the circlip 4607.156 along the main rotor shaft 4450.43 from the top, and allow it to engage in the channel. Please note the following points here:

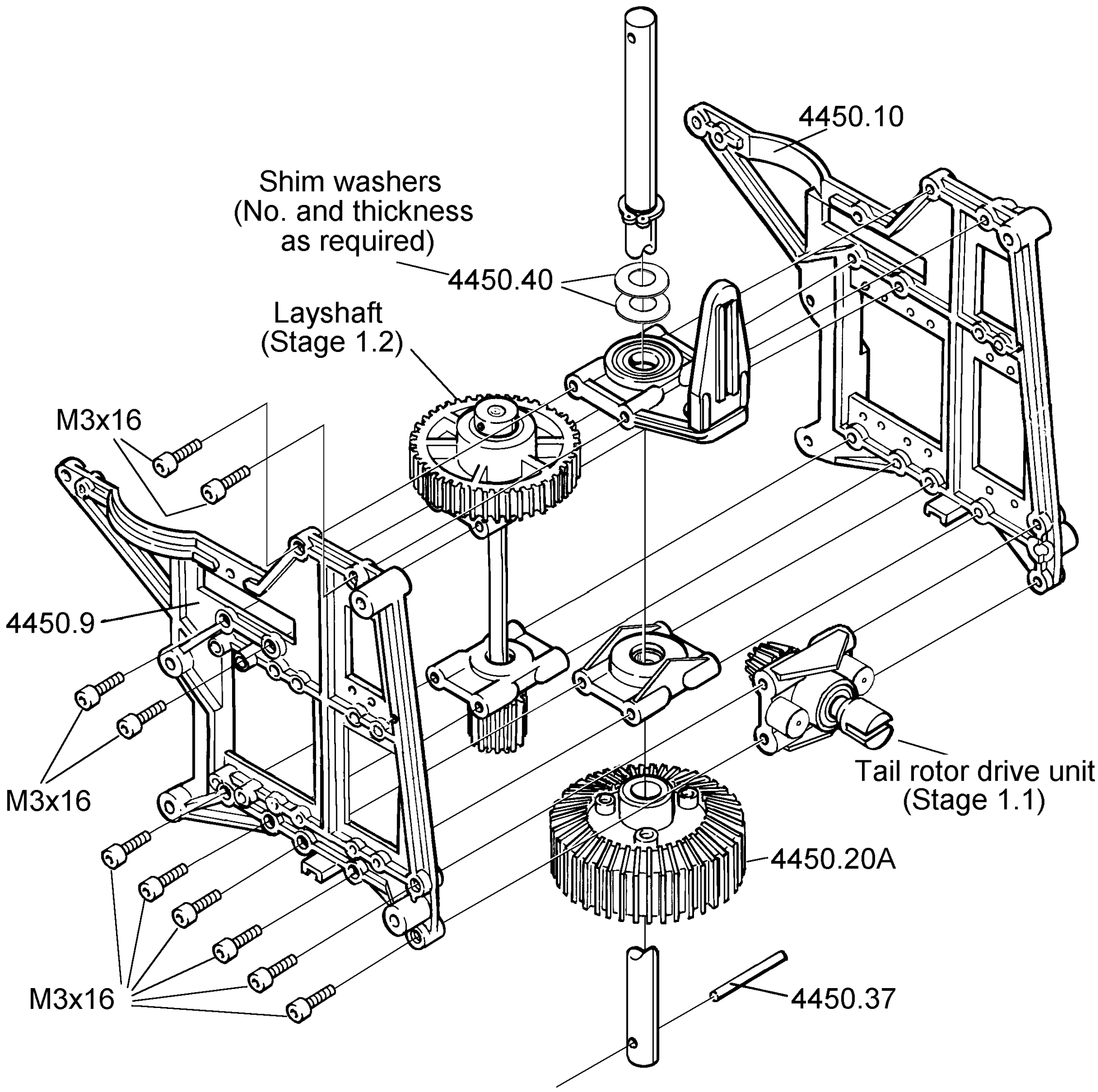
- The circlip must not be over-stressed, i.e. take care not to open it further than absolutely necessary in order to slide it onto the main rotor shaft. Special circlip pliers are the best tool for this job.
- The inner face of the circlip features one rounded and one sharp edge; the sharp side must face up.
- The circlip must be a really tight fit on the shaft; it should not be possible to rotate it by hand.



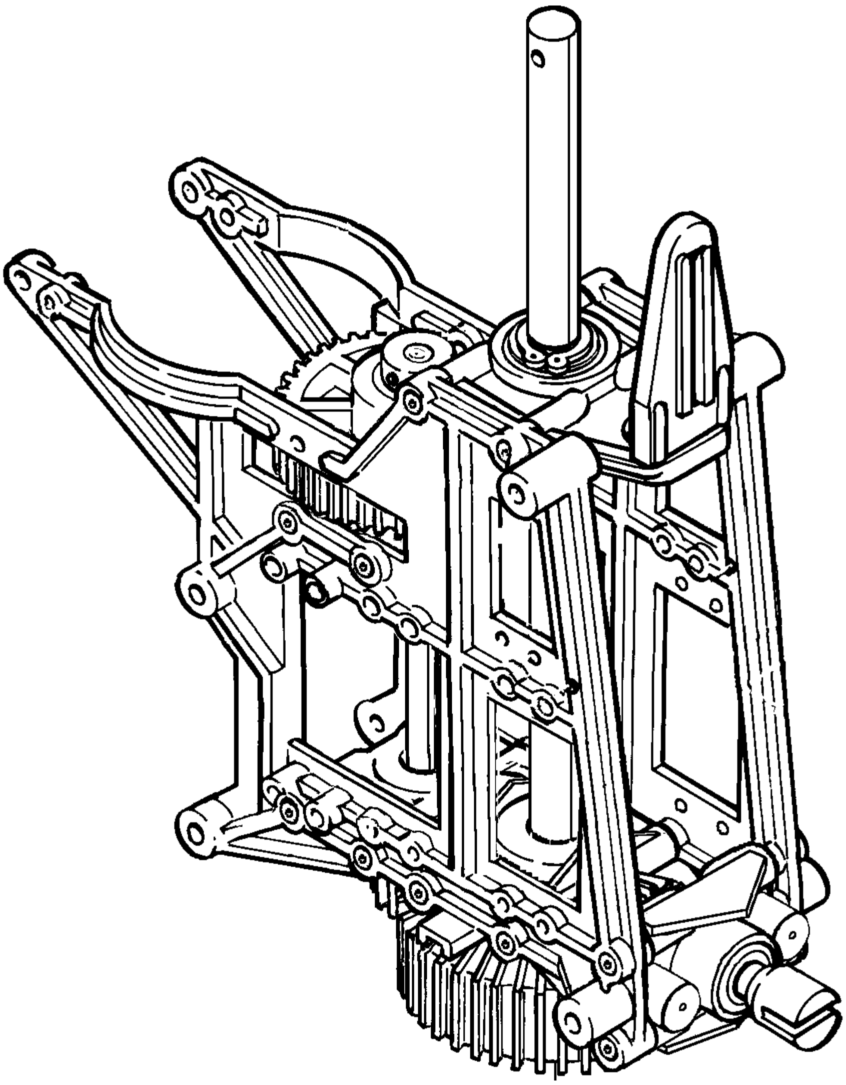
1.4 Assembling the main gearbox

Fit the tail rotor drive unit, the layshaft assembly and the main rotor shaft bearing holders between the mechanics side frames 4450.9 and 4450.10, and fix them in place using M3 x 16 socket-head cap screws; don't tighten the screws fully at this stage. Fit a shim washer 4450.40 and the dome bearing holder on the main rotor shaft from the underside. Slide the main rotor shaft through the bottom rotor shaft bearing and the crown gear 4450.20A, working from the top, and position it in such a way that the dowel pin 4450.37 can be pushed through the bottom hole in the main rotor shaft. Now pull the main rotor shaft up as far as it will go, and check that the dowel pin engages fully in the recess in the underside of the crown gear. Now you can fix the dome bearing holder between the mechanics side frames using further M3 x 16 socket-head cap screws, and check that there is absolutely no axial play in the main rotor shaft between the bearings; if there is, fit further shim washers under the circlip to eliminate it. Take care not to fit too many or too thick washers, as this could place the bearings under stress.

To add or remove shim washers always loosen the dome bearing and remove the main rotor shaft by reversing the order of operations required to install it (see above). On no account remove the circlip to gain access to the washers!



The first step in establishing the correct gearbox clearance is to set the meshing clearance of this gearbox stage slightly too tight, i.e. the gears should mesh „hard" against each other. If this is not the case, i.e. if there is already significant clearance between the gears after you have assembled the main mechanical system and screwed the parts together, then you will have to turn the bottom main rotor shaft bearing 4448.12 through 180° and re-install it. If that is still not sufficient to eliminate the gear clearance, you will also have to turn the bottom layshaft bearing bracket through 180° horizontally. Turning these parts round in this way compensates for any slight offset of the brass inserts in the bearing supports; such offsets are an inevitable feature of the production process and can never be completely eliminated. The meshing clearance between the spur gear and the layshaft pinion can now be adjusted by slightly loosening the M3 x 16 socket-head cap screws in the bearing brackets, fitting a strip of stout writing paper between the gears, and then tightening the screws again, holding the gears hard against each other. Wind the strip of paper out, and the gearbox should now run smoothly, with no tendency to jam or stiffen at any point; if you are not satisfied, repeat the adjustment process with a little greater care.

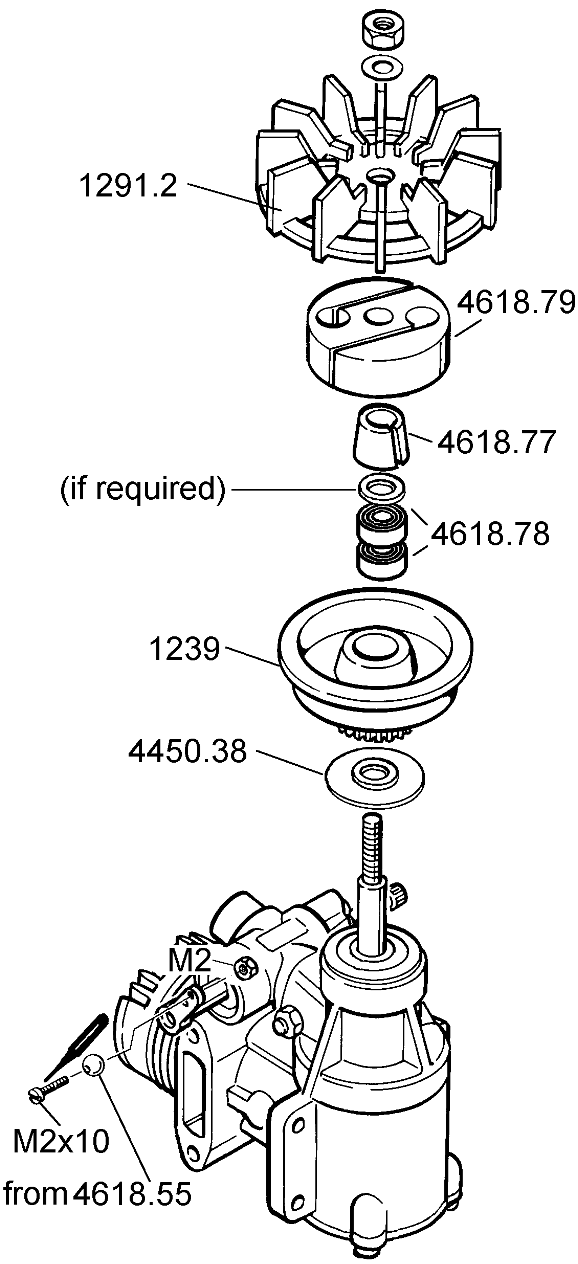


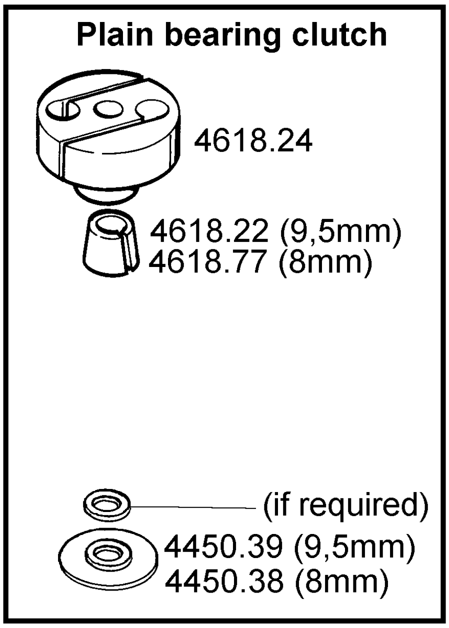
1.5 Installing the motor *(bag UM-2)*

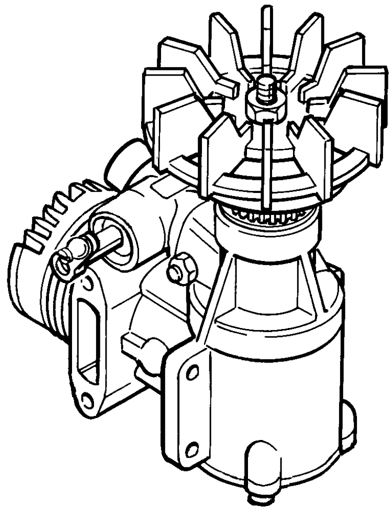
The mechanical assembly of this helicopter is designed for a motor with a long ground 8 mm Ø crankshaft, as specified for all Graupner / Heim model helicopters. However, other types of motor can also be installed at the modeller’s discretion; all you need is the optional plain bearing clutch, which is available separately.

Remove the washers and nut from the crankshaft, then fit the following parts on the shaft in this order: stepped washer 4450.38, two ballraces 4618.78, split taper collet 4618.77, clutch bell 4618.23, clutch 4618.79, cooling fan 4450.2, followed by the washer supplied with the motor. Fit the crankshaft nut and tighten it securely.

If you find that tightening the crankshaft nut pushes the taper collet completely inside the clutch, without the collet exerting adequate clamping pressure on the crankshaft, then you must fit an 8/13 x 0.5 mm washer (from 4450.58) under the taper collet, otherwise the clutch may slip on the crankshaft when the motor is running. Fix a linkage ball to the outermost hole in the carburettor arm using an M2 x 10 screw and nut.

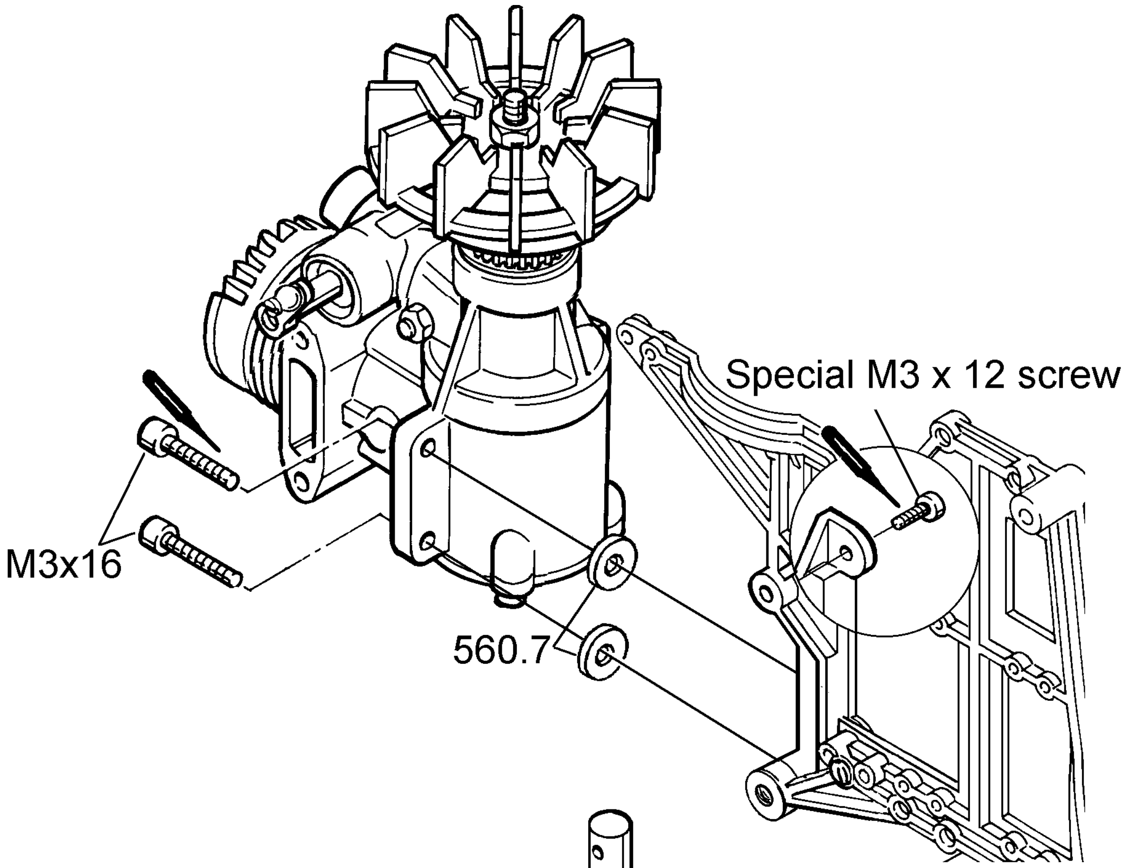


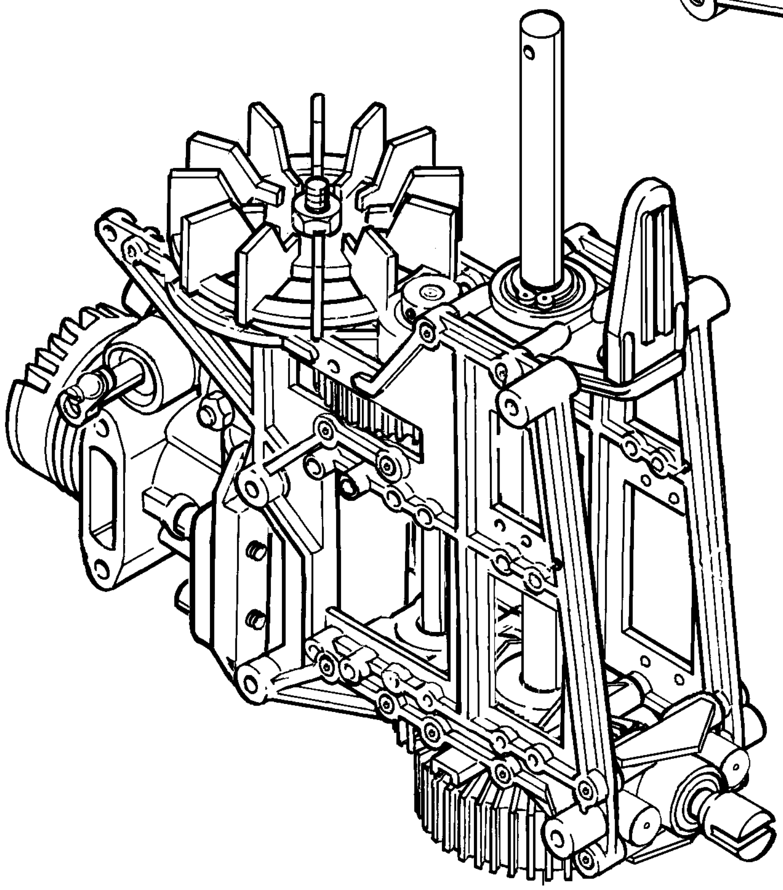




Notes:
Power transference between crankshaft and clutch is achieved exclusively by the clamping pressure of the taper collet on the ground crankshaft nose, and on the tapered socket in the clutch. To ensure that sufficient pressure is applied, it has proved good practice to start by installing the clutch alone - without the cooling fan - and tightening it fully; the clutch should be held firmly using a suitable tool while you do this.
When attaching the clutch bell to the crankshaft it is essential to ensure that the shaft is not pushed out of position in its bearings!
Once you have fitted the clutch and tightened it correctly, the only way to remove it again is to use a puller mechanism (Order No. 1045), after removing the crankshaft nut. Note that the tightness of the crankshaft nut makes no significant contribution to power transmission when the motor is running; the nut’s primary purpose is to secure the cooling fan and, if used, the hexagon starter cone (optional part, Order No. 4448.103).

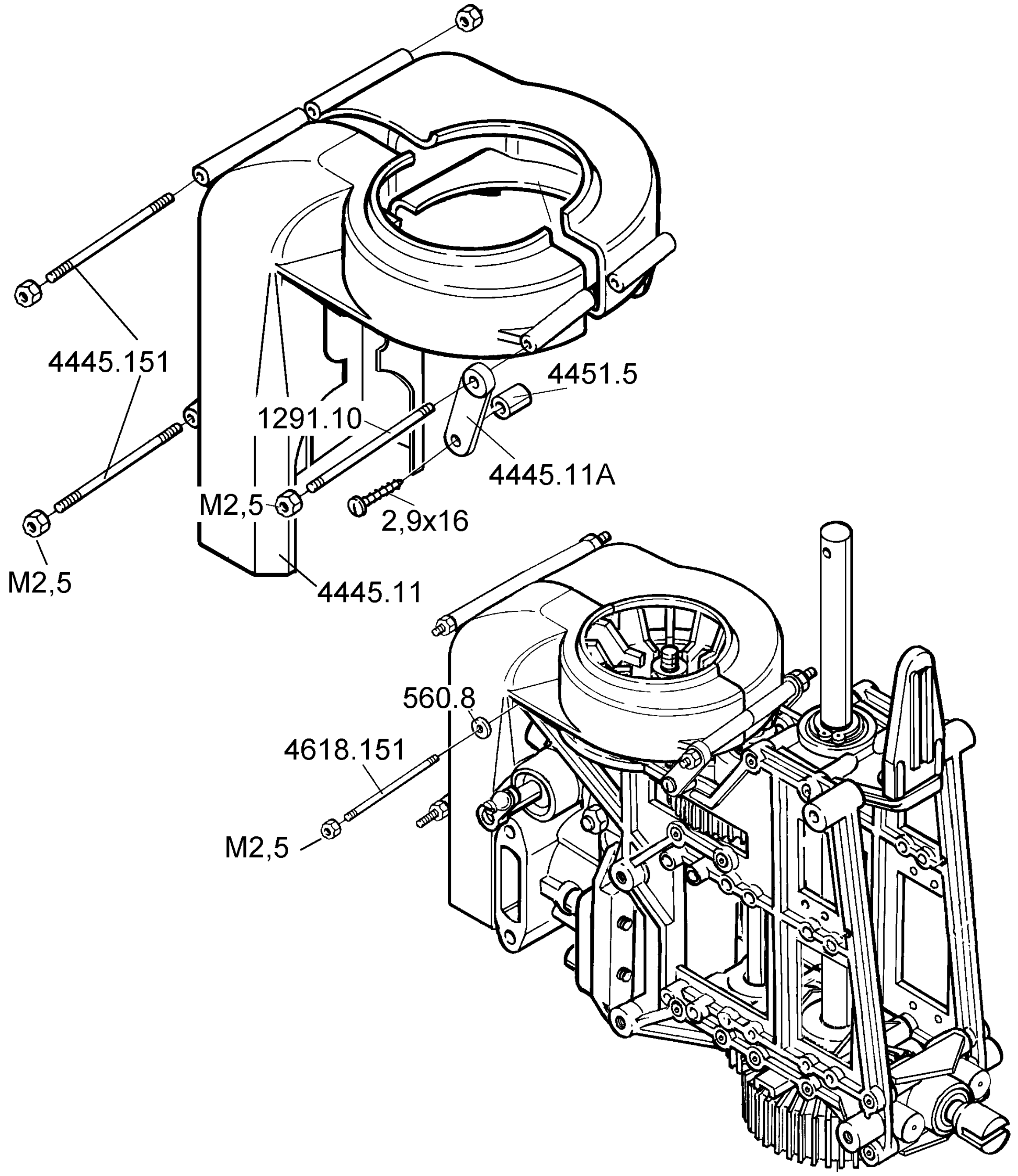
Fix the motor mounts 1291.18 to the top part of the mechanics using the two special M3 x 12 screws, working from the inside of the assembly. Attach the motor to the motor mounts using four M3 x 16 socket-head cap screws, fitting a washer 560.7 on each screw between the motor lugs and the motor mounts (see drawing).





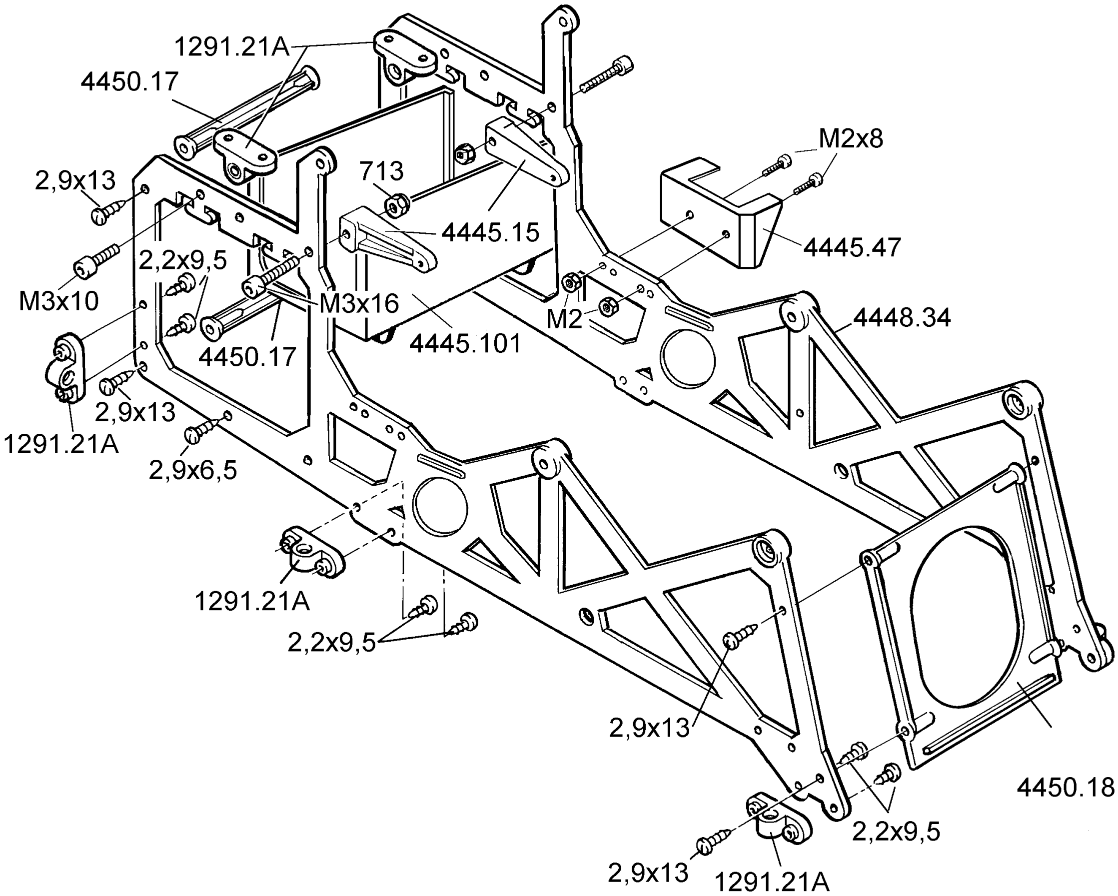
1.6 Assembling the cooling fan housing *(bag UM-3)*

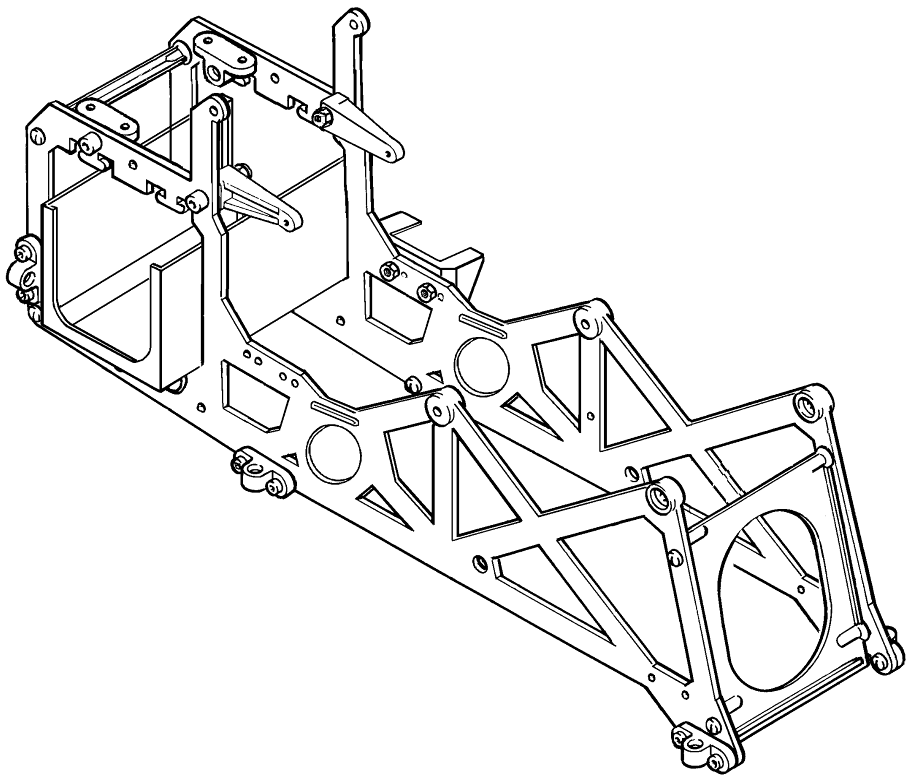
You may find that you have to open up the carburettor opening in the fan housing, depending on the type of carburettor you are using; the same applies to the hole for the cylinder head.
Fit the fan housing over the motor and fix it to the mechanics using a threaded rod 4618.151, washers and nuts at the front, and two 2.9 x 16 mm self-tapping screws at the rear.



1.7 Assembling the sub-structure *(bag UM-4)*

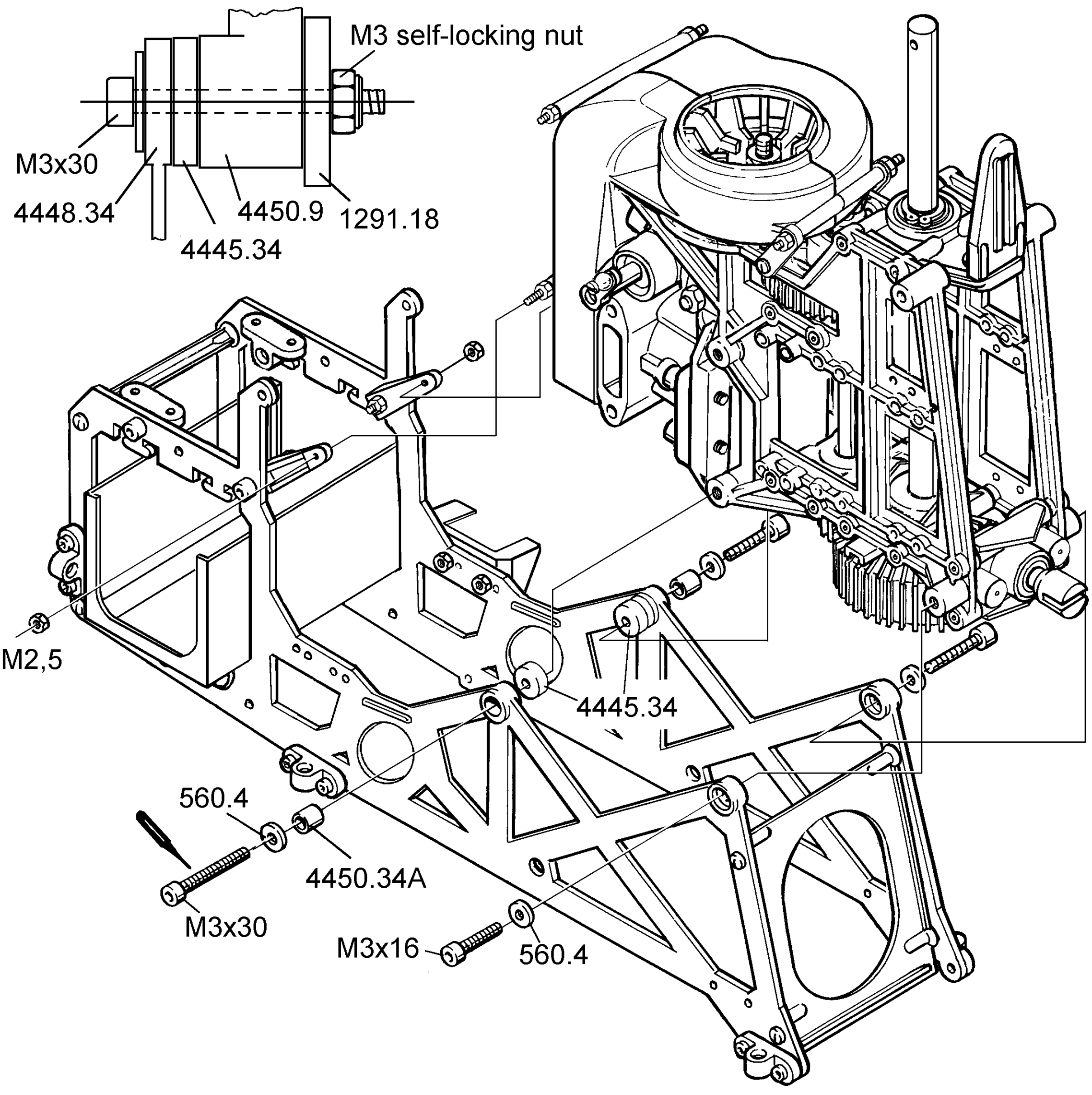
Assemble the sub-structure as shown in the illustration, using the side frames 4448.34, the bulkhead 4450.18, the spacers 4450.17, the RC box 4445.101 and the skid brackets 1291.21A, using the appropriate self-tapping screws, as shown in the drawing.





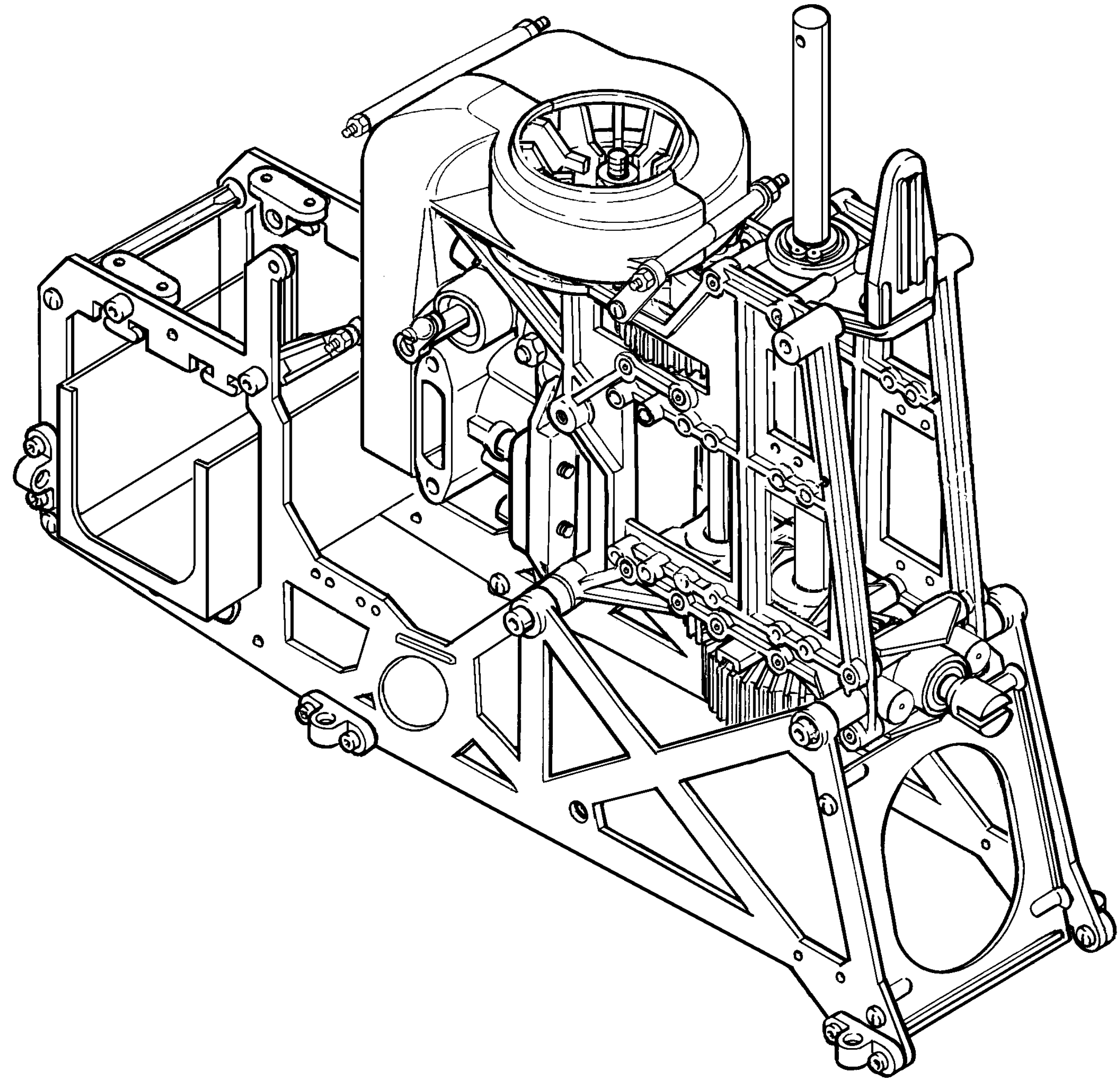
1.8 Mounting the mechanics on the sub-structure *(bag UM-5)*

Fit the circular projections on the main gearbox (assembled in Section 1.6) between the side frames of the sub-structure, and allow them to engage in the moulded-in sockets. Fix the parts together using M3 x 16 socket-head cap screws and washers as shown.

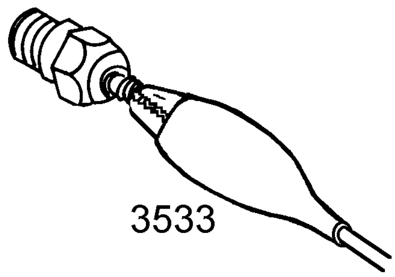


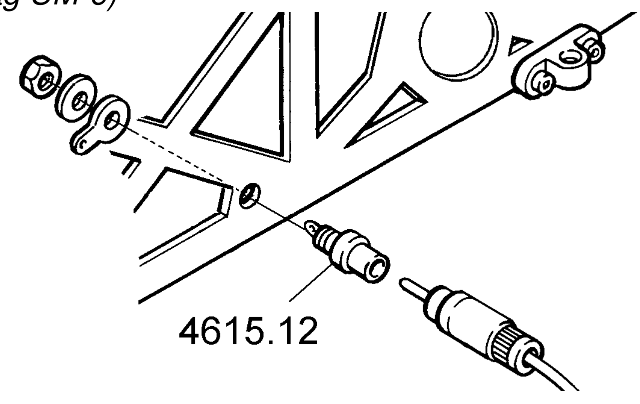
Note that two M3 x 30 socket-head cap screws are used in the middle; fit a washer under each screw head, fit the brass sleeves 4450.34A in the sub-structure side frames, and fit the screws through the two spacer washers 4445.34 and into the mechanics side frames. When you tighten these screws, the ends will project through the bottom motor mount screw holes. Fit M3 self-locking nuts on the projecting shanks to secure the motor mounts.

The next step is to set the proper meshing clearance in the first gearbox stage: loosen the M3 x 16 screws which attach the top layshaft bearing support to the side frames, and also the M3 self-locking nuts at the bottom of the motor mounts, then cut a strip of thin card and wind it in between the clutch pinion and the gear. Hold the gears firmly together, and tighten all the screws again firmly in this condition. Apply plenty of thread-lock fluid to the M3 screws in the motor mounts before you tighten them. Wind the strip of paper out from between the gears, and the entire gearbox should now rotate freely; note that there should be no detectable play where the bevel gear engages with the crown gear.



1.9 Glowplug connector *(bag UM-6)*

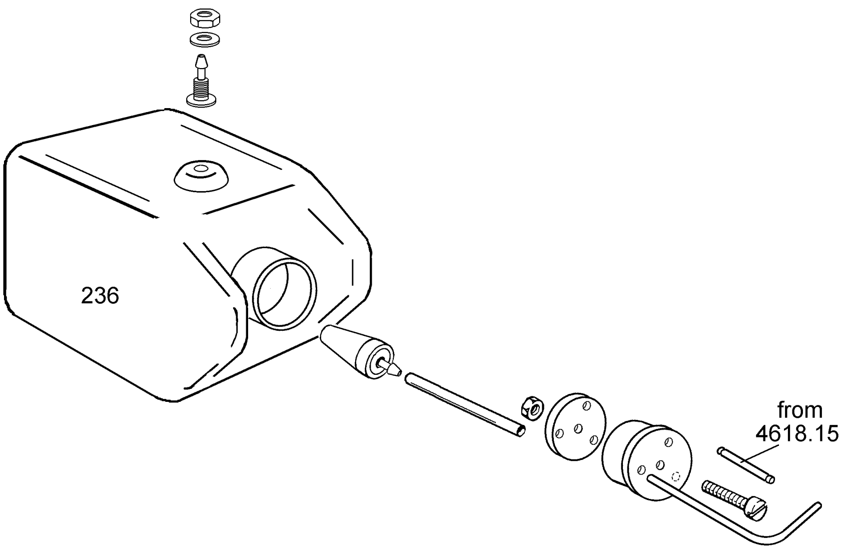




Fit the socket of the glowplug connector in the hole in the right-hand side frame 4448.34, and fit the solder tag, the washer and the nut on it on the inside to secure the socket. Tighten the nut. Make up the connection to the motor using twin-core cable. A crocodile clip is used for the centre contact, so that the glowplug can be replaced quickly and easily; solder the croc-clip to the wire running from the centre contact of the socket, and attach the clip to the glowplug. Fix the other wire to one of the motor mount screws with a washer to spread the load. Arrange the cables neatly, and solder the two wires to the positive and negative terminals of the socket.

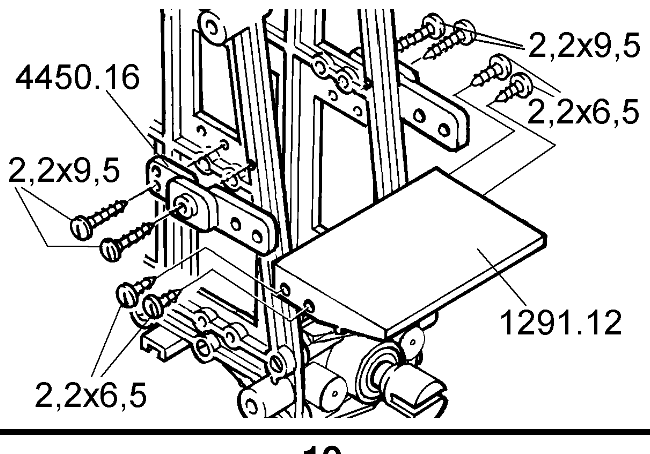
1.10 Fueltank

The fueltank is assembled as shown in the drawing. First install the pressure nipple in the small raised area at the highest point in the tank: cut a 5 mm Ø hole, slip the nipple through it from the inside, and secure it with the washer and nut on the outside. The rubber bung features a central hole for the retaining screw, two through-holes for brass tubes, and a third „blind" hole. The latter can easily be continued through the bung and used for other purposes if you wish. For this model only a single fuel line is required (carburettor feed / filler tube), so the second hole should be plugged with a length of brass rod (4618.15). Bend the feed tube to the shape shown in the drawing. Ensure that the clunk weight is free to move inside the tank, i.e. that it always falls to the bottom when the tank is turned over by hand. Fit the brass collar over the neck of the fueltank, as it guarantees that the neck cannot split when the rubber bung is compressed. Tighten the central retaining screw firmly once the fueltank is completely assembled. This action compresses the rubber bung and causes it to swell laterally, sealing the throat of the tank effectively.
Carefully remove any rough edges from the fueltank support surfaces at the side-frames, Order No. 4448.34. Install the tank, and secure it by stretching rubber bands over it as shown; note that the bung must face the rear. Make up the fuel line to the motor using fuel tubing and the fuel filter T-piece; keep the connection to the carburettor as short as possible.
The tank is filled and drained by means of the fuel line running between the clunk pick-up and the carburettor, and this is made easier by the presence of the fuel filter T-piece. For flying the helicopter, push the sealing plug into the filler connection projecting from the side of the filter. For filling or draining the tank, first cut off the fuel flow to the carburettor by engaging the hose clip, then fill or empty the tank through the filler connection.



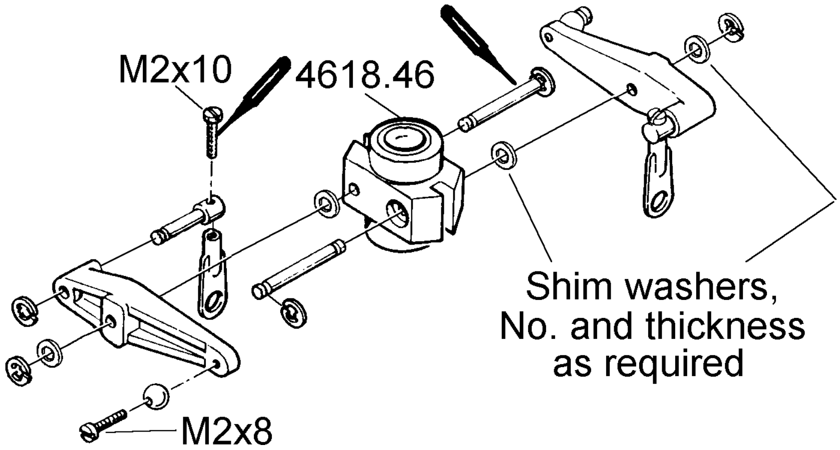
1.11 Installing the gyro platform *(bag UM-7)*

Fix the gyro platform holders 4450.16 to the side frames using 2.2 x 9.5 mm self-tapping screws. At a later stage the gyro platform 1291.12 can be fixed to the supports using four 2.2 x 6.5 mm self-tapping screws, but only after the servos have been installed.



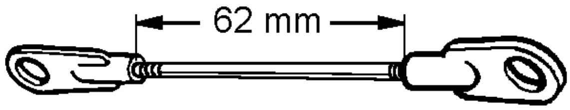
1.12 Collective pitch compensator and swashplate *(bag UM-8)*

The collective pitch compensator 4618.47A is assembled as shown in the drawing.

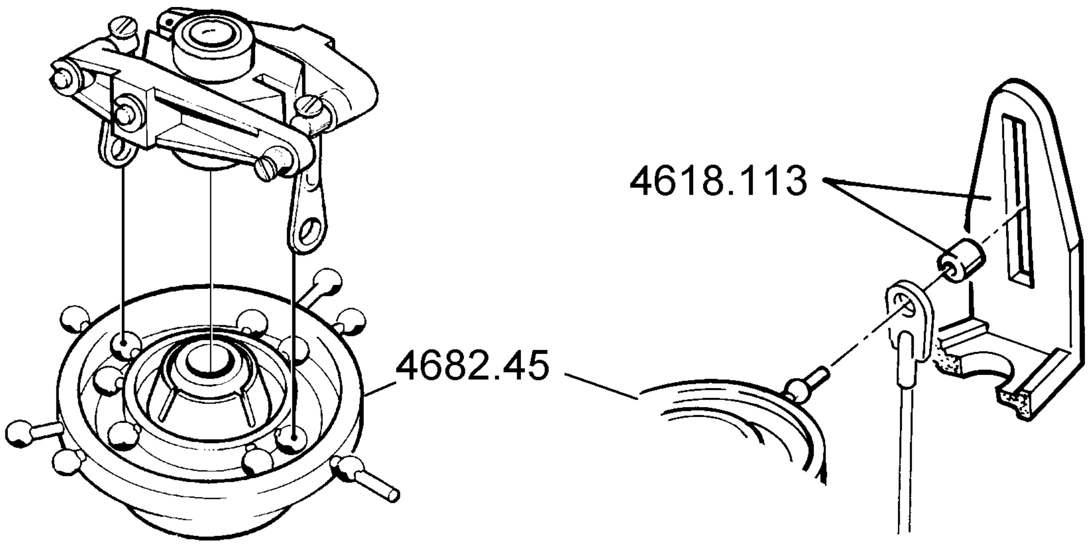


First fit a circlip on each of the brass rods, and glue them in the holes in the collective pitch compensator hub 4618.46 using bearing retainer fluid, ensuring that the circlips engage fully in the recesses. De-burr the collective pitch compensator arms and slip them on the projecting ends of the brass rods, fitting at least one shim washer between the hub and the arm in each case. Note that the arms must be free to rotate on the rods; de-burr the holes if necessary. Fit the outer circlips, and check that there is no axial play in the arms on the rods; if there is detectable play, extra shim washers must be fitted.

Make up three pushrods as shown in the drawing, using the threaded rods 4618.51 (2 mm Ø, 75 mm long) and six ball-links 4618.55. The stated dimension refers to the actual clearance between the ball-links, as shown.



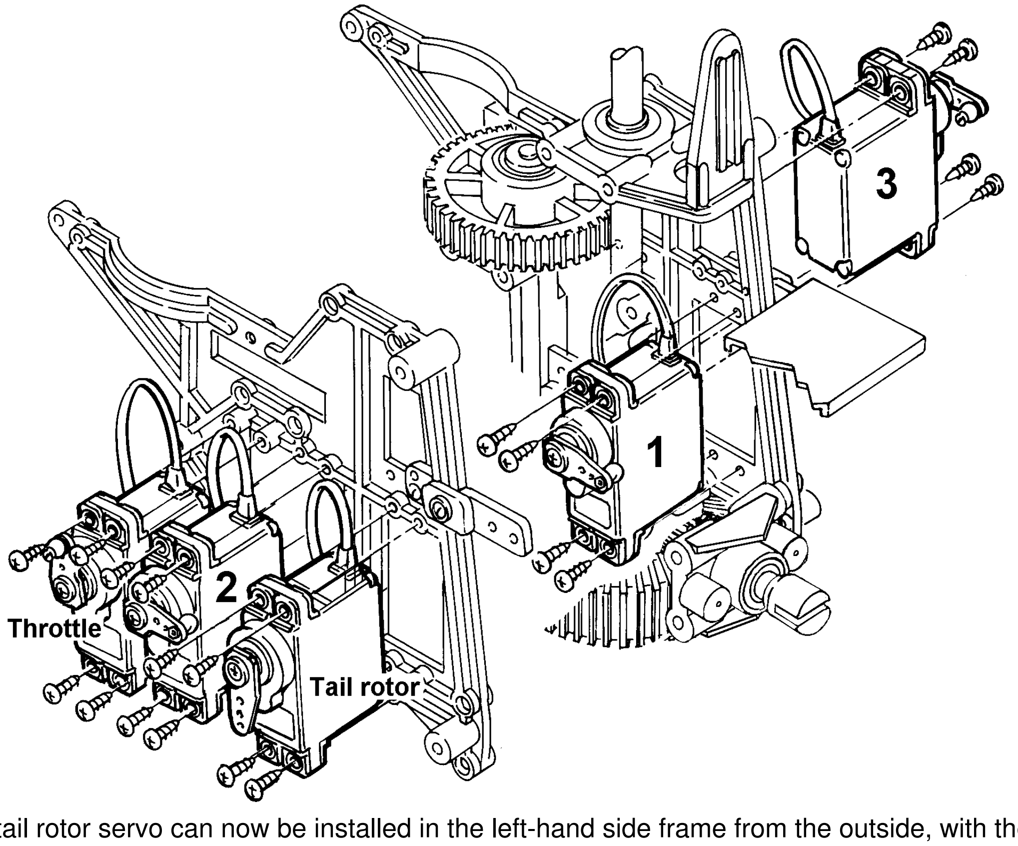
The first pushrod is fitted to the rear linkage point on the swashplate. Slip the ball-link over the guide pin on the swashplate 4682.45 and snap it onto the linkage ball. Now fit the brass sleeve (from 4618.113) onto the guide pin and grease it well. Slip the swashplate onto the main rotor shaft, routing the attached pushrod down through the opening behind the dome bearing holder; at the same time carefully ease the swashplate guide 4618.113 back, so that the brass sleeve on the swashplate guide pin engages in the channel in the swashplate guide.
Fit the collective pitch compensator on the main rotor shaft, and press the two ball-links onto the appropriate linkage balls on the swashplate inner ring, as shown in the drawing.



2. Installing the radio control system *(bag UM-9)*

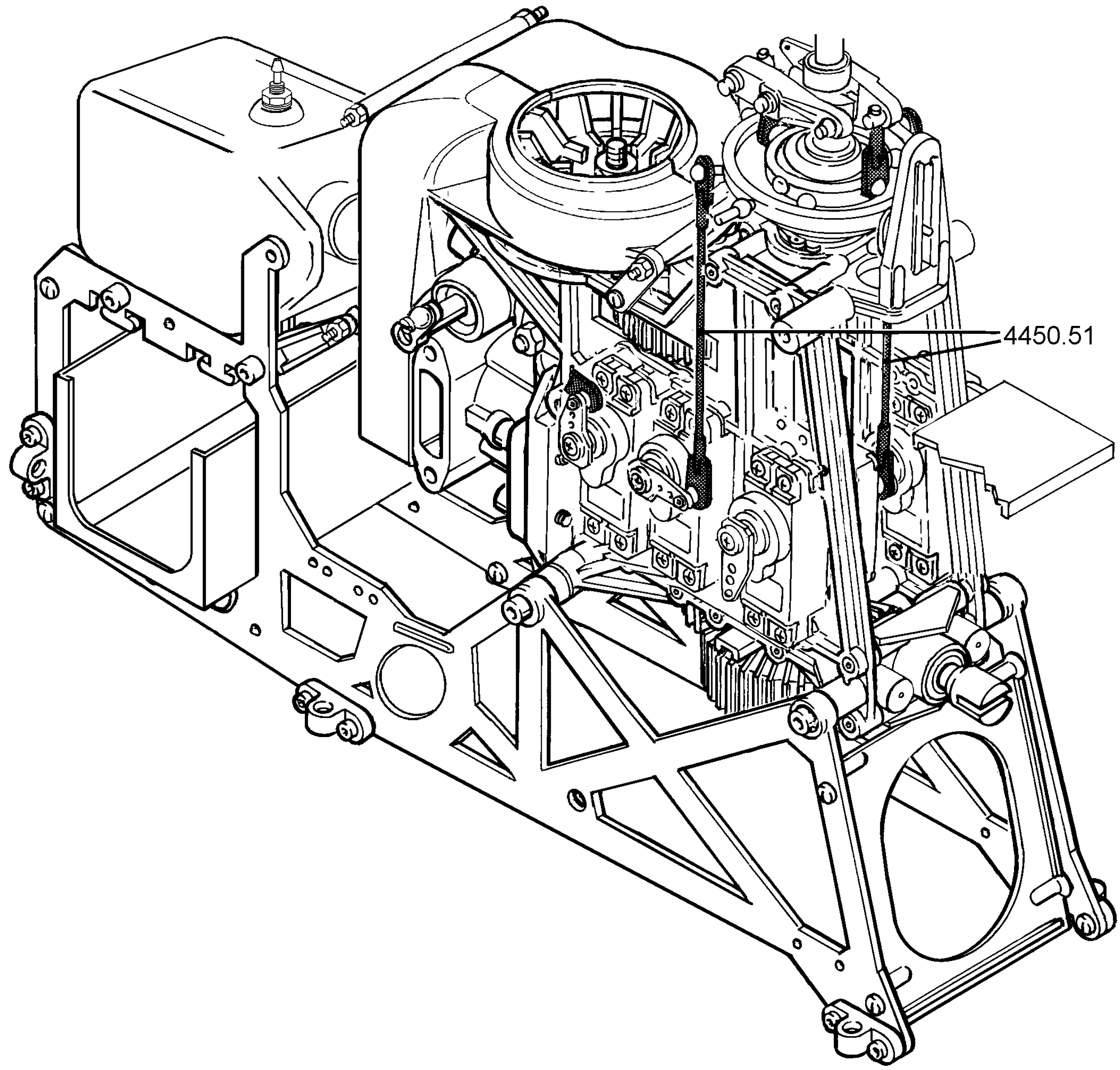
2.1 Mounting the servos

Attach brass linkage balls *to the inside* of the pitch-axis servo arm (1), and the output arms of the roll servos (2) + (3), using M2 x 10 screws, and secure them with M2 nuts on the outside. Apply thread-lock fluid between screw and ball and also in the nut. The distance from the servo output shaft axis to the ball centre should be about 18 mm. The first servo to be installed is the pitch-axis servo, which should be placed in the servo aperture in the right-hand side frame from the inside, with the output shaft at the top. Secure it with four screws, rubber grommets and tubular metal spacers (these parts supplied with the servos). Note that the tubular spacers should be fitted in the rubber grommets from the underside, and the screws fitted from the top. *The servo mounting holes in the mechanics are intentionally offset slightly towards the outside; this places the rubber grommets under slight tension when the screws are fitted, and this in turn improves overall control precision.*
Install the roll servos in the right and left side frames from the outside, with their output shafts also at the top (see drawing). Secure each with four screws as already described. Connect the servos to the receiver in the sequence explained in the RC system instructions, then switch on the RC system and activate the swashplate mixer at the transmitter (setting: symmetrical three-point linkage, two roll servos, 1 pitch-axis servo at the rear). Set the collective pitch, pitch-axis and roll controls to neutral, and fit the output arms on the servos, at right-angles to the rotor shaft. Fit and tighten the output arm retaining screws.



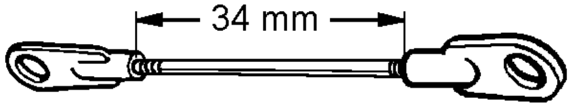
The tail rotor servo can now be installed in the left-hand side frame from the outside, with the output shaft again at the top. Fit the retaining screws. The servo output arm should point straight down, and should be parallel to the main rotor shaft when the collective pitch stick is at centre. Fix a brass linkage ball *to the outside* of the throttle servo output arm, and secure it with an M2 x 10 screw, secured with an M2 nut from the rear. Remember to apply thread-lock fluid between screw and ball and also in the nut. The distance from the output shaft axis to the ball centre should be about 11 mm. Mount the throttle servo in the left-hand side frame with the output shaft at the top and the servo output arm facing up.
The servo leads can now be routed through the remaining vacant servo aperture at the front of the right-hand side frame, and routed forward along the right-hand side of the mechanics to the receiver. Bundle the wires together in spiral tubing. Please take great care when deploying the servo leads; eliminate any chance of wires contacting shafts or gears, as the model could easily crash if the wires chafe and rub through.

The next stage is to link the swashplate servos to the swashplate using the pushrods already prepared, to form a 120° linkage.

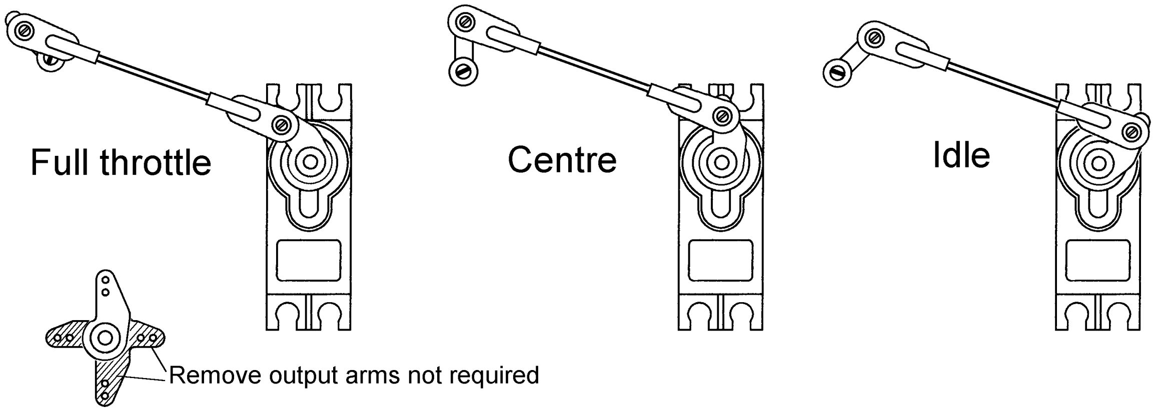


A four-point swashplate linkage is also possible; details of this alternative installation are left up to the builder. In this case one further servo is installed in the vacant servo aperture in the mechanics, and connected to the appropriate linkage point on the swashplate by means of a 2.5 mm Ø pushrod, which has to be angled to suit. The pushrods from servos 2 and 3 are then connected to the lateral (90°) linkage points on the swashplate. You will need to activate a four-point swashplate mixer at the transmitter.
If you decide to install a four-point linkage, it is very important to adjust the pushrods really accurately, otherwise the opposed servos may be under constant strain. This is the procedure: switch on the radio control system and set the collective pitch stick to centre (servo output arms at 90° to the pushrods). Disconnect one swashplate pushrod. Adjust the three remaining pushrods until the swashplate is exactly horizontal. The length of the fourth pushrod should now be adjusted very carefully so that it can be pressed onto the swashplate linkage ball without moving it, i.e. without straining any other servo.

Make up the throttle pushrod as shown in the drawing, using the threaded rod 4445.84 (2 mm Ø, 45 mm long) and two ball-links 4618.55; the stated dimension refers to the actual clearance between the ball-links.



Connect the carburettor arm to the throttle servo output arm using this pushrod, as shown in the drawings:



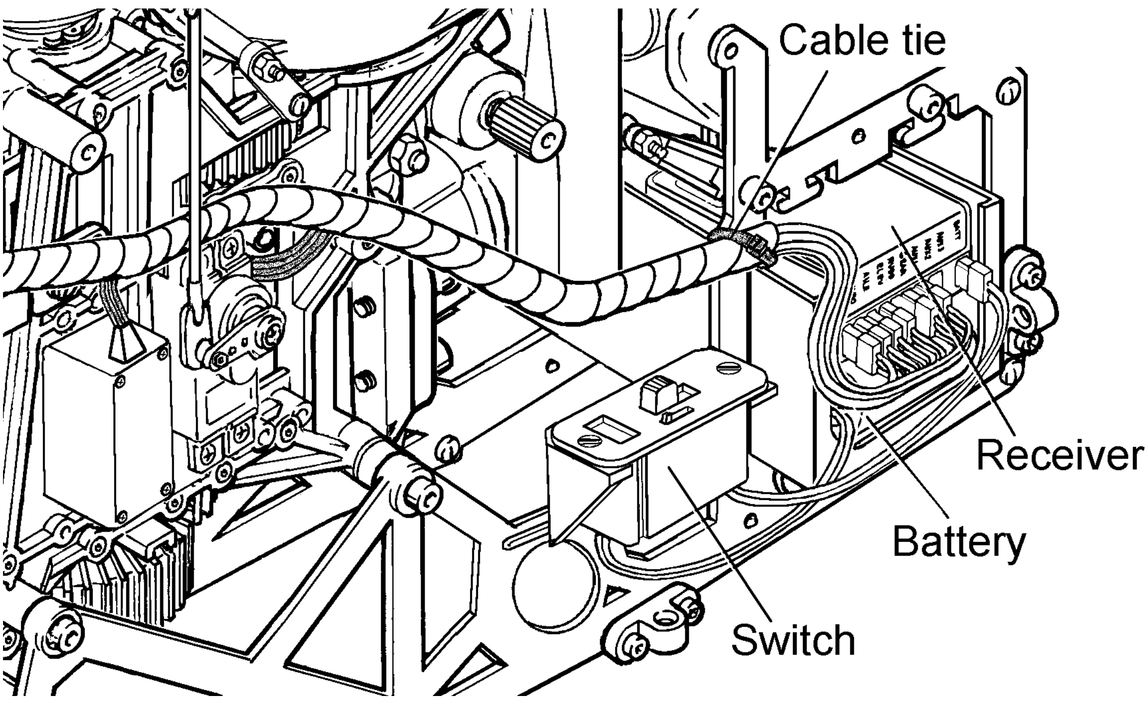
2.2 Installing the remaining radio control system components

To attach the gyro system to the gyro platform we recommend the use of double-sided foam tape, e.g. Order No. 742. The cables should be grouped with the servo leads and routed forward along the side of the mechanics to the receiver.

Pack the receiver battery in foam rubber, with the receiver above it, and stow these components in the RC box, where they are secured with rubber bands. Note that the receiver sockets should be on the right-hand side, so that the servo cables can be plugged in directly, without the need for extension leads.

Bundle the cables together with spiral tubing, and attach them to the mechanics using cable ties. It is important that the wires are not under stress, make no contact with rotating parts, and do not rub or chafe against any sharp edges or corners.

Install the receiving system switch on the switch console, which is screwed to the right-hand side of the sub-structure. Connect the switch to the battery and receiver in the usual way.

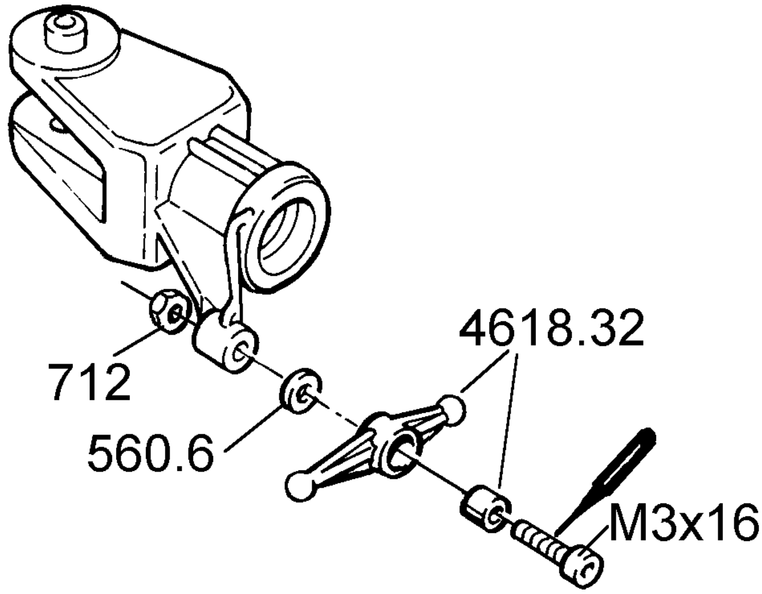


3. Assembling the main rotor head *(bag UM-10)*

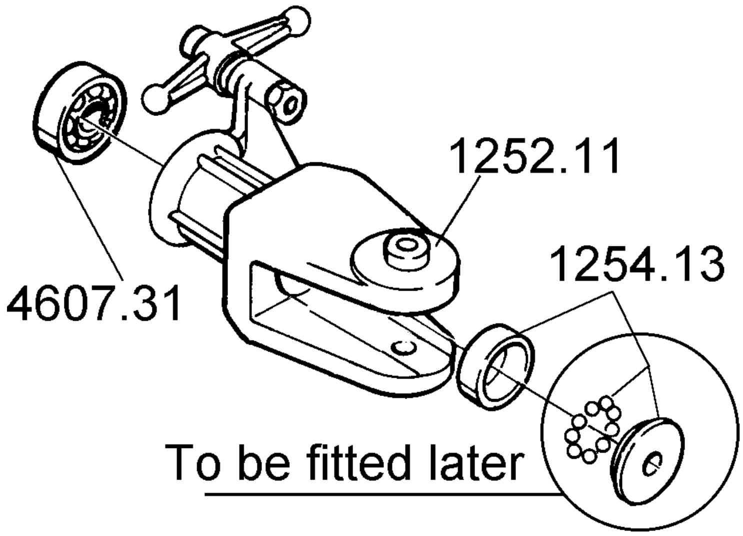
The main rotor head is assembled as shown in the illustrations. All ballraces must be greased.

3.1 Preparing the blade holders

The first step is to glue the brass sleeves from 4618.32 to the M3 x 16 screws using thread-lock fluid. Allow the fluid to cure. Check that the mixer levers 4618.32 swivel freely on the brass sleeves; if not, remove any rough edges from the mixer lever bores, and lubricate with silicone oil. The mixer levers are screwed in place using the M3 nuts.



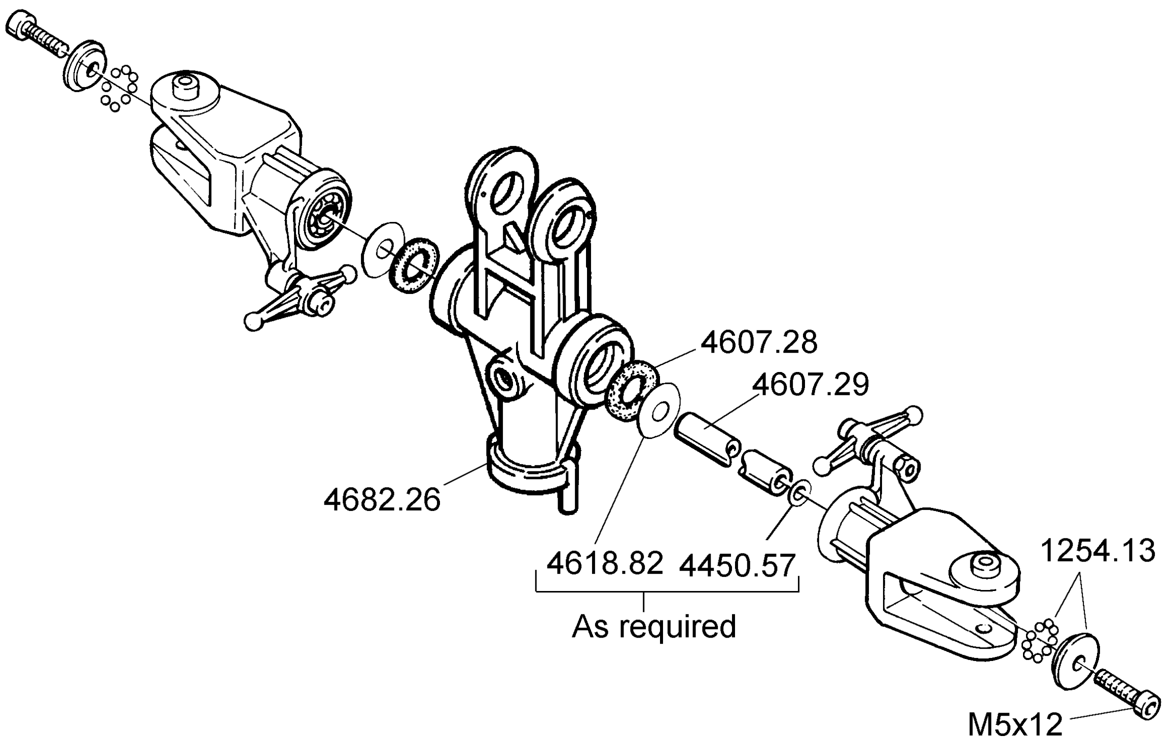
Press the radial bearings 4607.31 and the shell of the combination bearings 1254.13 into the blade holders 1252.11 as shown in the drawing. Push them in as far as they will go.



Now check that the prepared blade holders, complete with the bearings 4607.31, can be slid easily onto the blade pivot shaft 4607.29. If necessary, rub down the blade pivot shaft with fine abrasive paper (600-grit or finer) until the bearings are a sliding fit on the shaft.

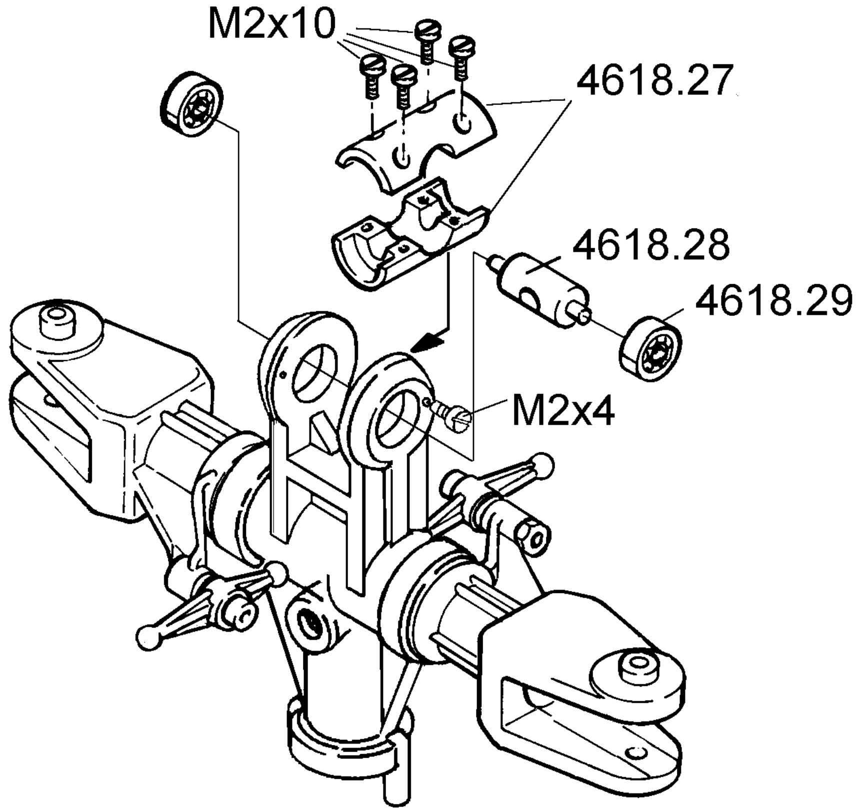
3.2 Installing the blade holders

Press the two O-rings 4607.28 into both sides of the rotor head hub 4682.26, grease the blade pivot shaft and slide it through the O-rings. Set it exactly central, i.e. projecting by an equal amount on both sides. It is important that the shaft does not push the O-rings out of their seatings. Now hold this assembly with the blade pivot shaft standing vertical. Fit a 0.2 mm shim washer from 4450.56 on the shaft from the top, followed by a blade holder, noting that the holder must be the correct way round: the mixer lever on the blade pitch arm must be located in front of the blade (see drawing). The blade pivot shaft should now project into the shell of the combination bearing 1254.13 at the top.
Fill the bearing shell with grease, and place exactly 14 steel balls in the shell, where the grease will prevent them rolling about.
During this procedure the blade pivot shaft must always project far enough into the bearing shell to prevent the balls falling inward, between the blade holder and the blade pivot shaft.
To complete the first end of the blade pivot shaft, fit the thrust washer of the combination bearing on top, with the ball channel facing inward, and tighten the M5 x 12 socket-head cap screw.
Turn this assembly over, so that the blade holder you have just installed is at the bottom, and fit the second blade holder on the blade pivot shaft using the same procedure, not forgetting the 0.2 mm shim washer.
Take great care not to allow the blade pivot shaft to project too far through the hub and blade holder, otherwise the balls may fall out of the combination bearing you first assembled!
The second combination bearing can now be completed following the procedure outlined above. Tighten the M5 x 12 socket-head cap screw.
Check that both blade holders rotate freely, and if necessary tap the holders and hub with the handle of a screwdriver so that the bearings seat themselves properly; this procedure helps to remove any stress from the bearings.
If the blade holders are stiff to move because they are being pressed against the hub, fit a spacer washer 4450.57 between the thrust washer of one of the combination bearings and the blade pivot shaft.
If you have to dismantle the combination bearing, take care that no balls fall out!
Once you are confident that the blade holders swivel freely, apply thread-lock fluid to the M5 x 12 socket-head cap screws and tighten them fully. If it was necessary to fit a spacer washer 4450.57, be careful when tightening the socket-head cap screws, otherwise the brass washer could be pushed out of shape.

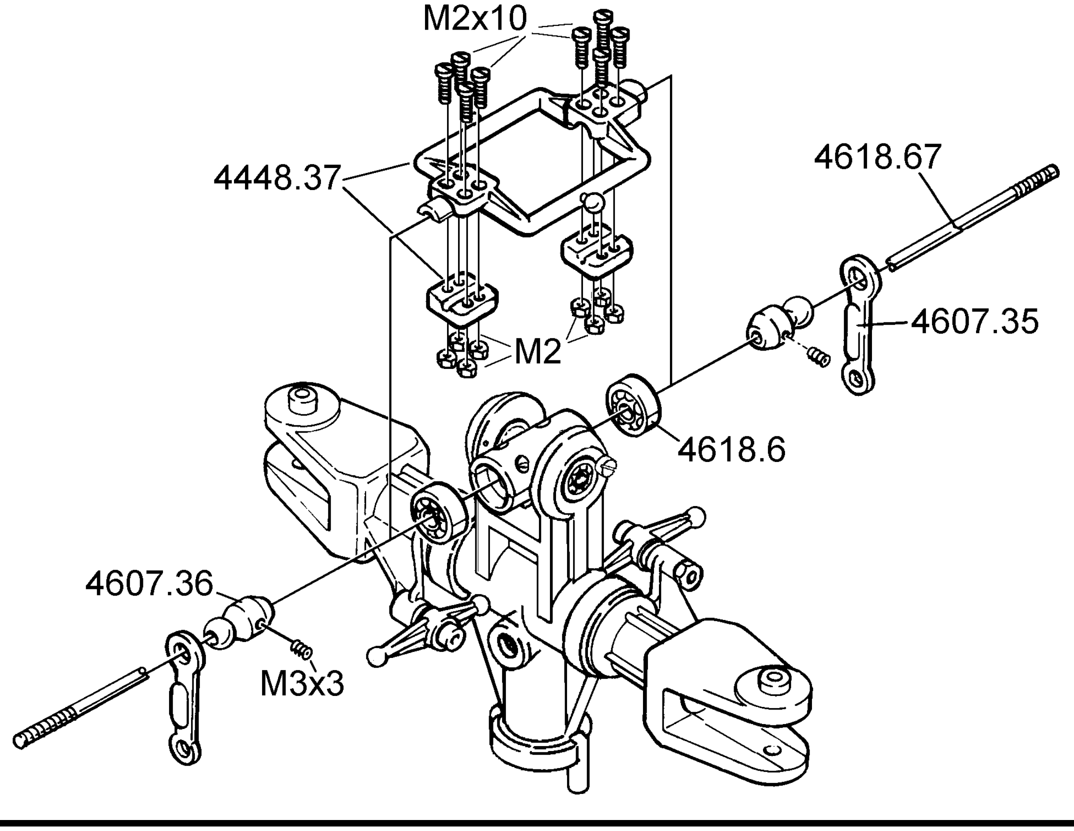


3.3 Assembling the Hiller rotor

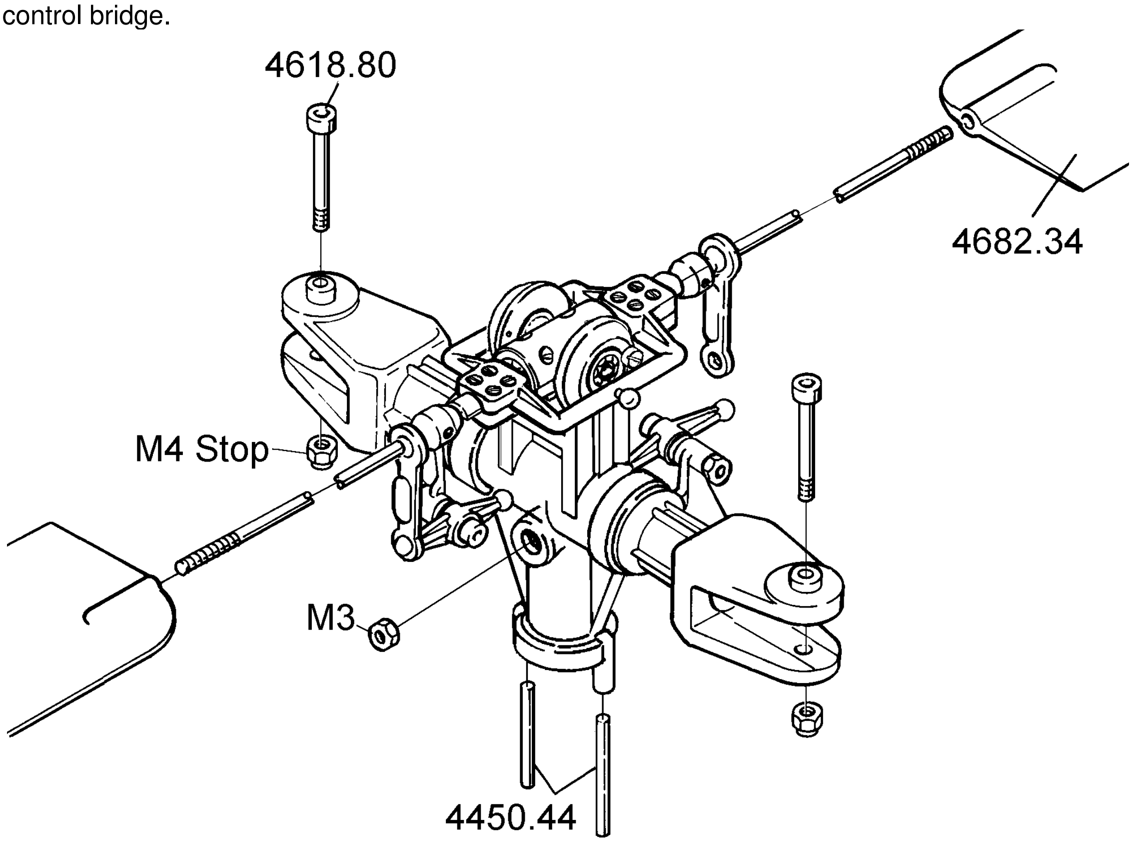
Assemble the rocker 4618.27 as shown in the drawing. Note that the hole in the pivot bar 4618.28 must line up with the through-hole in the rocker, to ensure that the flybar can be slid through later without jamming or binding. Fit an M2 x 4 screw on the outside on each side to fix the two ballraces to the hub. Check that the rocker rotates freely.



Press the ballraces 4618.6 into both sides of the rocker 4618.27. Slide the flybar 4718.67 through the rocker and set it exactly central, i.e. projecting out of the bearings by an equal distance on both sides.

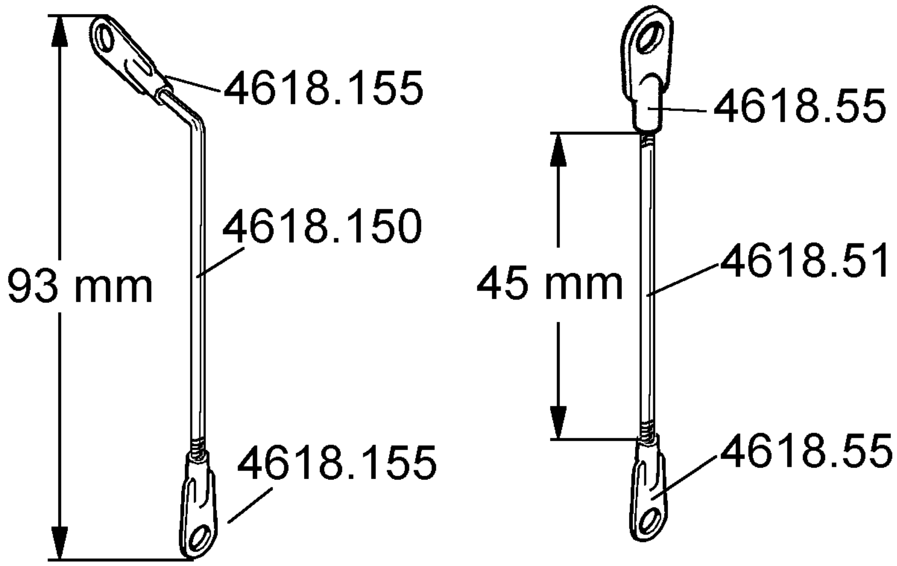


Roughen the surface of the flybar at the point where the control bridge 4618.37 is to be clamped. Screw the control bridge to the flybar, applying thread-lock fluid between the bar and the control frame to prevent any danger of the flybar rotating in the control bridge during violent aerobatic manoeuvres.
Slip the ball-collets 4607.36 on both ends of the flybar, and position them resting against the control bridge. Before fitting the M3 x 3 grubscrews apply a drop of thread-lock fluid to the threaded holes in the ball-collets. Press the double ball-links 4607.35 into place as shown.
Apply thread-lock fluid to the sockets in the flybar paddles 4682.34, and screw them onto the ends of the flybar to a depth of exactly 15 mm. Set them exactly parallel to each other and to the control bridge.



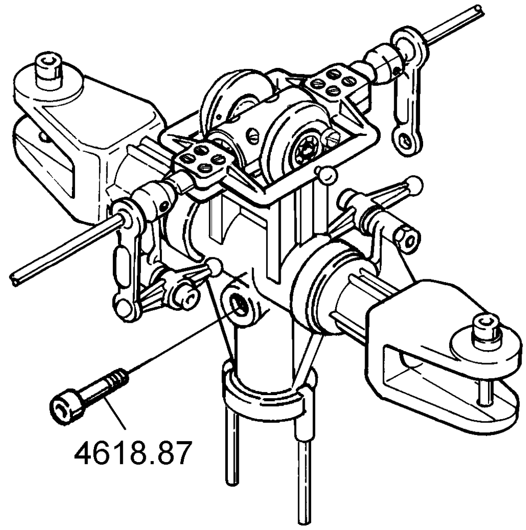
Press an M3 nut into the recess in one side of the rotor head hub, and press the two guide pins 4450.44 for the collective pitch compensator into the holes, applying thread-lock fluid to the sockets first.

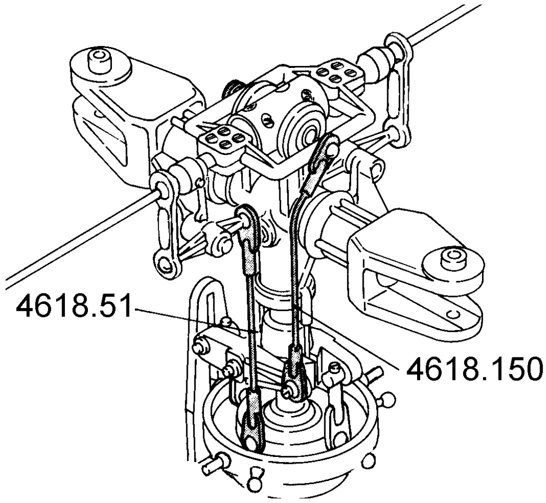
Make up two straight and two angled pushrods as shown in the drawing.



3.4 Installing the main rotor head

Fit the main rotor head on the main rotor shaft.
Align the hole in the rotor head with the top cross-hole in the main rotor shaft, then fit the special screw 4618.87 to fix the parts together.





The next step is to install the pushrods 4618.150 and 4618.151 which you have just prepared; their positions are shown in the drawing. Note that the arms of the mixer levers 4618.32 are of different length: the double ball-links attached to the flybar must be pressed onto the longer lever arms, whereas the straight pushrods run from the shorter, inner levers to the swashplate.

The angled pushrods 4618.150 now have to be adjusted in order to obtain maximum possible collective pitch adjustment range. This is the procedure:

Disconnect the ball-links on the swashplate outer ring (if necessary), and slide the swashplate up as far as it will go. The swashplate should now rest against the collective pitch compensator when the compensator itself is resting against the bottom face of the main rotor head.

If this is not the case, the angled pushrods must be adjusted as follows:

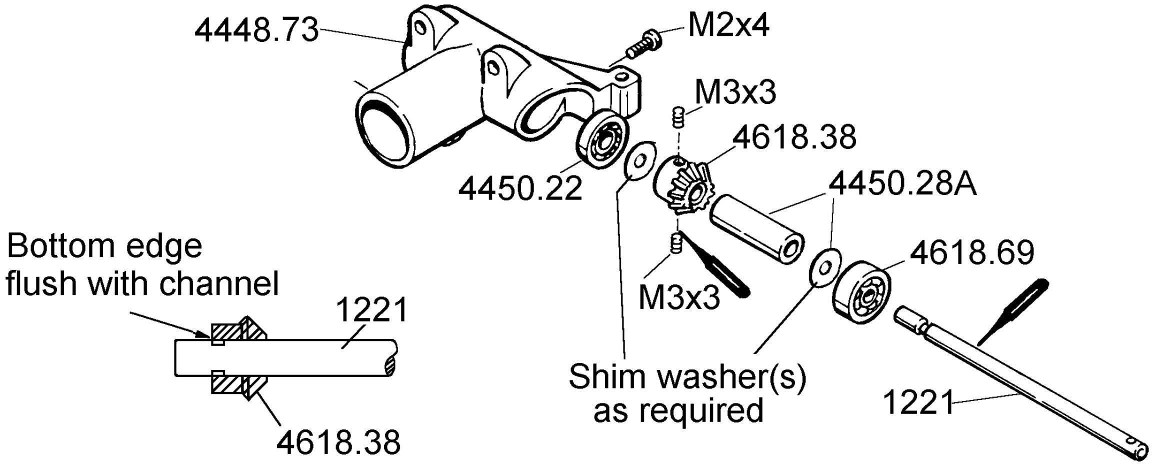
- The swashplate rests against the collective pitch compensator, but there is a gap between the collective pitch compensator and the rotor head: ⇨ shorten both pushrods.
- The swashplate rests against the rotor head, but there is a gap between the swashplate and the collective pitch compensator: ⇨ lengthen both pushrods.

It is essential to adjust the length of both pushrods by the same amount, i.e. they must always be exactly the same length.

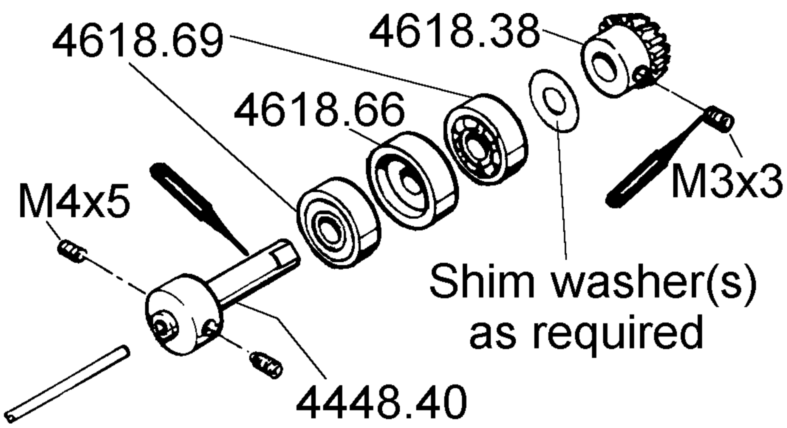
Now carry out the fine adjustment of the auxiliary rotor, ensuring that the Hiller paddles run parallel to the swashplate when the swashplate is exactly horizontal. If you need to adjust the length of the pushrods 4618.150, always adjust them in opposite directions by the same amount; never adjust only one of them!

4. Assembling the tail rotor gearbox *(bag UM-11, 11A)*

Fit the bevel gear 4618.38 on the tail rotor shaft 1221 as shown in the drawing. Apply a drop of thread-lock fluid to the threaded holes in the bevel gear, then fit the M3 x 3 grubscrews. One of the two grubscrews must engage squarely on the machined flat in the tail rotor shaft. Take care not to tighten the grubscrews so much that they force the bevel gear out of shape, as this will prevent it running true. Fit the spacer sleeve 4450.28A and the bearings 4618.69 and 4450.22 on the tail rotor shaft, pushing them hard up against each other. Slide this assembly into the tail rotor gearbox 4448.73 as far as it will go, and fit the M2 x 4 retaining screw. Check that there is absolutely no axial play in the shaft; to take up any slack fit 5/10 x 0.1 mm shim washers in the position shown.

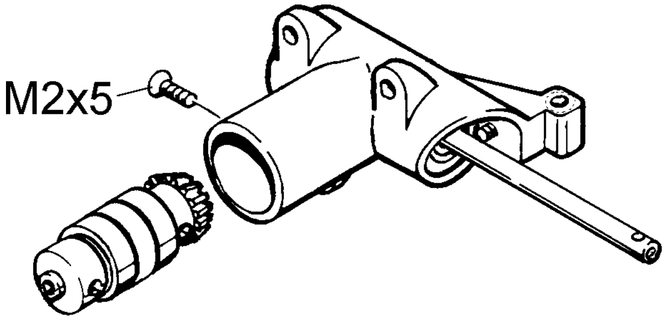


Fit the ballraces 4618.69 and the spacer 4618.66 on the tail rotor input shaft 4448.40 as shown in the illustration. Apply bearing retainer fluid, Order No. 951, before fitting the bearings.
The bearings must not be under stress; if necessary tap on them using a screwdriver handle or similar, so that they automatically seat correctly on the shaft. Allow the bearing retainer fluid to dry.
Fit a 5/10x0.1shim washer and a bevel gear 4618.38 on the tail rotor input shaft 4448.40 as shown in the illustration without using bearing retainer fluid at this stage.
Fit and tighten the M3 x 3 grubscrews in the bevel gear. Note that one of the two grubscrews must engage squarely on the machined flat in the tail rotor input shaft.



Now fit the prepared drive shaft assembly into the tail rotor housing, and line up the hole in the spacer 4618.66 with the hole in the tail rotor housing, then secure it with an M2 x 5 countersunk screw.
Fit a steel rod (screwdriver blade or similar) through the threaded holes in the coupling 4448.40. Using the rod as a handle, pull hard on the coupling (against the countersunk screw joint), so that the tail rotor drive assembly seats itself in the housing with maximum possible gear

meshing clearance between the bevel gears, as if under maximum load. Now check that the tail rotor gearbox runs smoothly, with just detectable meshing clearance in the bevel gears.

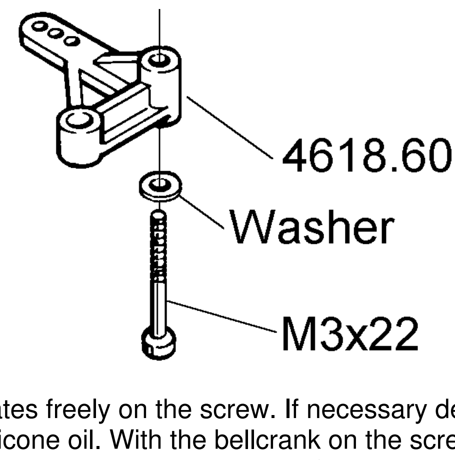


If the play in the gears is too slight, i.e. the gears are stiff to move, you will need to remove the drive assembly again and remove the shim washer under the bevel gear. If, however, there is too much play in the gear meshing insert additional shim washers. If you work carefully, making small adjustments, it is possible to set up the bevel gears so that they work freely but **without** backlash. Reinstall the unit, repeat the pulling procedure as described above, and you should find that the gear meshing clearance is correct.

***Note**: if you still cannot set the gear meshing clearance to your satisfaction, the problem may be that the bevel gear on the tail rotor shaft is located too far outward due to manufacturing tolerances, and is not engaging correctly with the bevel gear on the input shaft. If this is the case, you will find that the tips of the teeth of the bevel gear 4618.41 are already fouling the spacer sleeve 4450.28A, and yet there is backlash in the meshing clearance. In this case you must fit the shim washers between the bevel gear 4618.38 and the bearing 4450.22, instead of between the spacer sleeve and the bearing 4618.69, until the desired slight meshing clearance is present.*

Now remove both assemblies again, apply bearing retainer fluid, Order No. 951, to the bearings, the setscrews, and the bevel gear on the input shaft, re-fit them on the tail rotor shaft and the input shaft, and assemble the parts permanently.

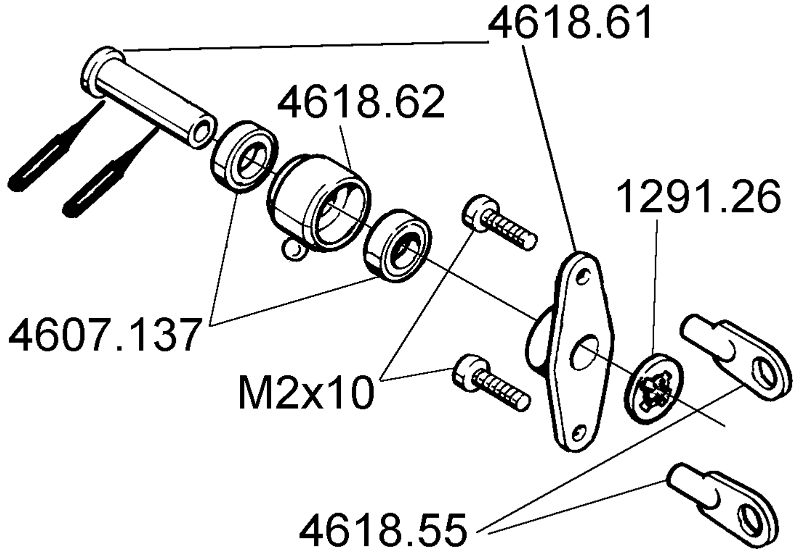
Fit a 3 mm Ø washer on the M3 x 22 socket-head cap screw, followed by the tail rotor bellcrank 4618.60.



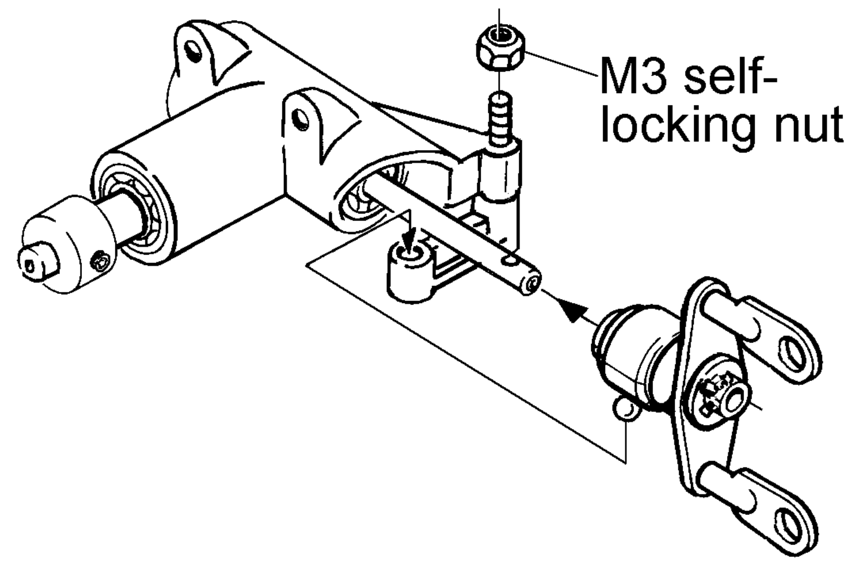
Check that the bellcrank rotates freely on the screw. If necessary de-burr the bore of the bell-crank and lubricate it with silicone oil. With the bellcrank on the screw, fit the screw in the hole in the shoulder of the tail rotor housing and tighten it by a few turns; do not secure it permanently at this stage because the control bridge, which is described in the next section, must first be installed.

5. Assembling the control bridge *(bag UM-11B)*

Press the ballrace 4607.137 into the control ring 4618.62 as far as it will go. Apply a little thread-lock fluid to the control sleeve 4618.61, taking care not to allow it to run between the control ring and the control sleeve. Push this assembly onto the control sleeve, with the inner ring of the ballrace resting against the flange of the control sleeve.

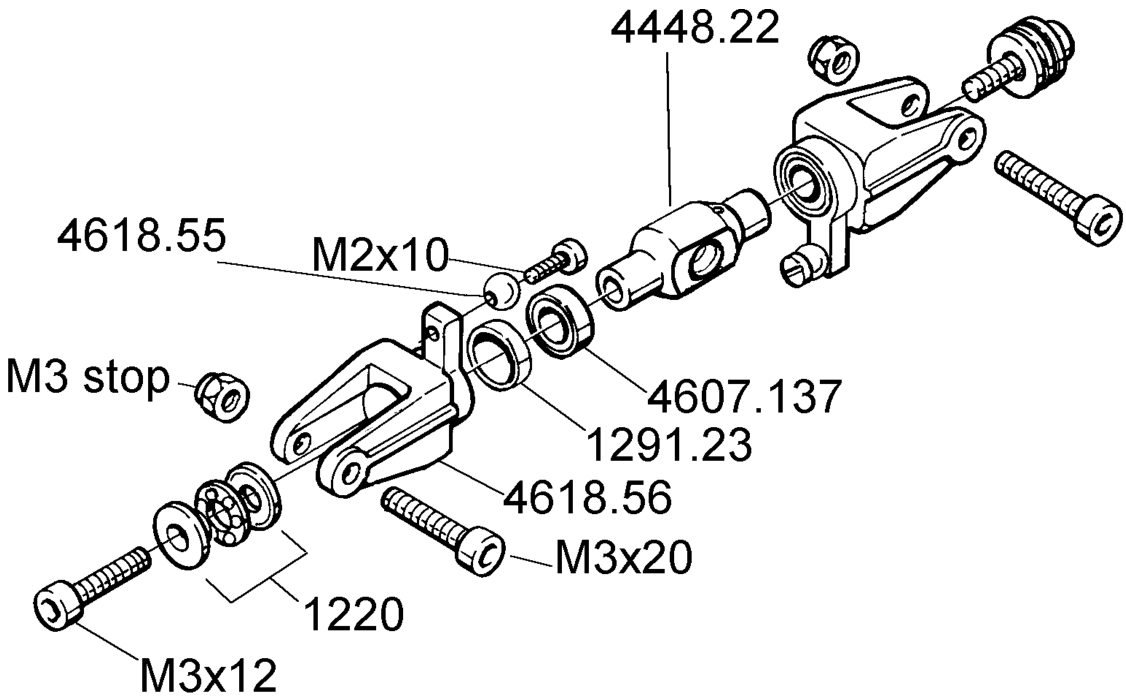


Fit the two ball-links 4618.55 on the control bridge 4618.61, slide it onto the control sleeve, and press it against the inner ring of the other ballrace. Press the shakeproof washer 1291.26 on the control sleeve and against the control bridge.
Check that the control ring can rotate easily on the control bridge, but without any axial play at all. If the ring is stiff to turn, it is likely that the two bearings are stressed against each other, and this can usually be corrected by tapping them with the handle of a screwdriver.
Fit the control bridge on the tail rotor shaft, then engage the actuator lever on the ball on the control ring, and tighten the M3 x 22 screw so that the lever and control bridge move freely but without slop; finally secure it using the M3 self-locking nut.



6. Assembling the tail rotor head *(bag UM-11C)*

Assemble the tail rotor head as shown in the drawing, greasing all bearings as you install them.

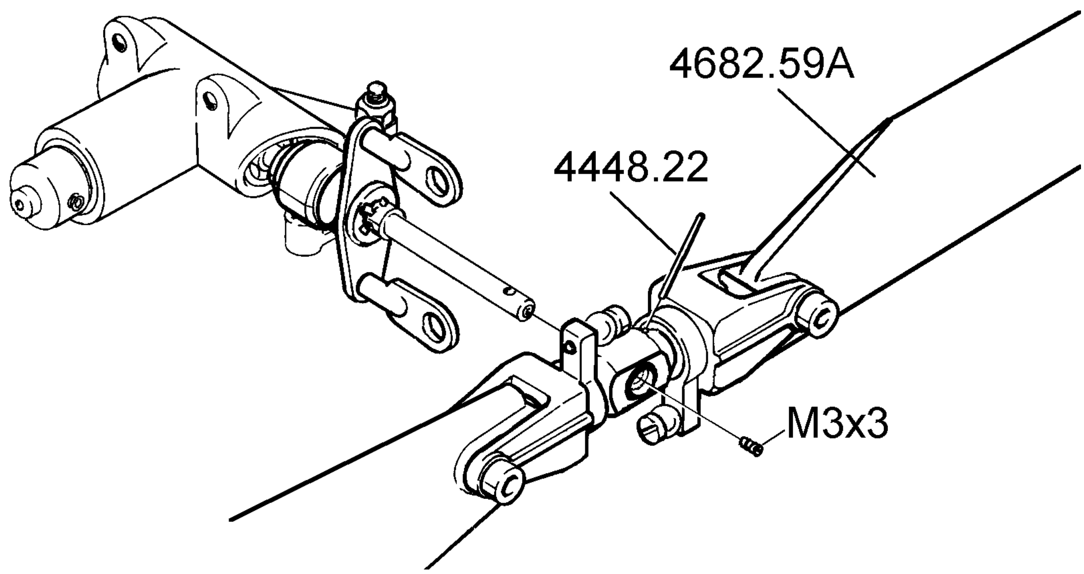


Place the two O-rings in the hub 4448.22 and press them into the channels. Oil the O-rings, fit the tail rotor head on the tail rotor shaft, and line up the cross-hole in the shaft accurately with the hole in the hub, and press the pin 4448.22 into place to fix the parts together. The pin is secured in turn by fitting the M3 x 3 grubscrew.

Note the correct orientation of the hub, as shown in the drawing.

Fix the tail rotor blades in the blade holders using the two M3 x 20 screws. The tail rotor blade fixing screws must not be over-tightened; the blades should just be free to swivel, so that they can align themselves in the optimum position when they spin up to speed.

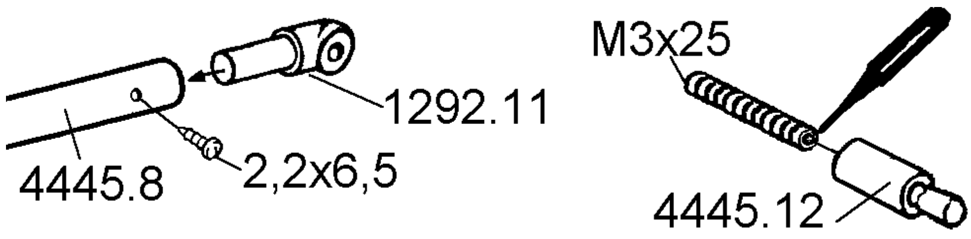
Note the orientation of the tail rotor blades: when viewed from the left-hand side, the tail rotor rotates clockwise („bottom blade forward"); and the blade pitch arms on the blade holders must be located in front of the blades.



7. Tail boom *(bag SR-0)*

7.1 Assembling the tail boom braces *(bag SR-1)*

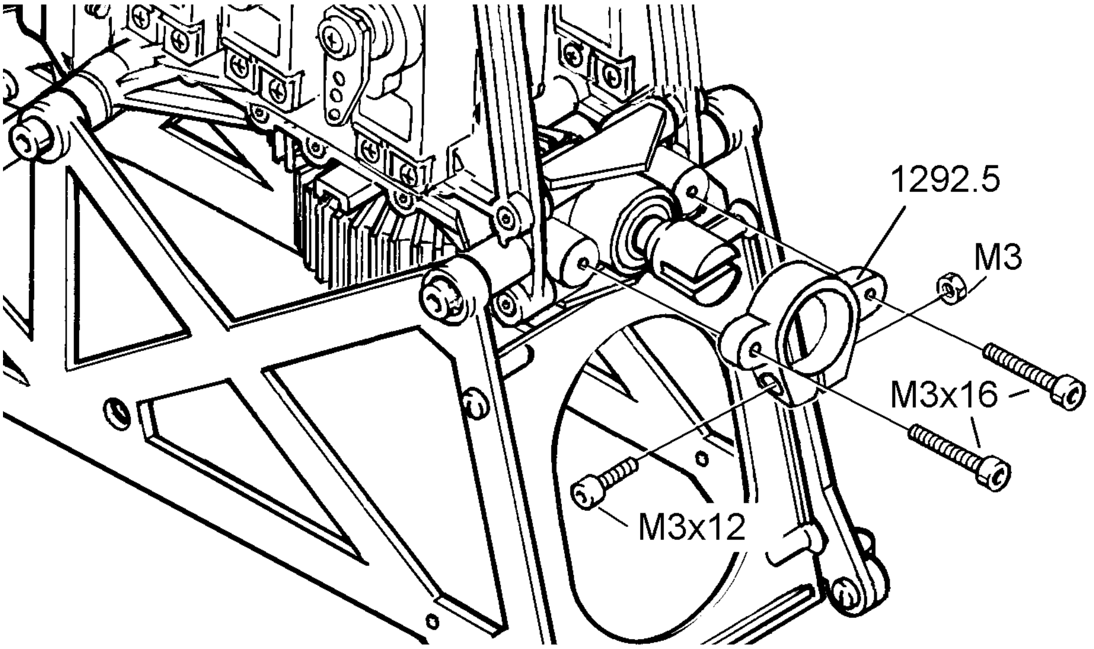
Press the strut end-pieces 1292.11 into both ends of the aluminium tail boom braces 4445.8 as far as they will go, and set the eyes parallel to each other. Drill a 1.5 mm Ø pilot-hole through each brace and into each end-piece, and fit 2.2 x 6.5 mm self-tapping screws to secure them.



Apply bearing retainer fluid to the M3 x 25 grubscrews and screw them into the two canopy stand-off pillars 4445.12 as far as they will go. Allow the fluid to cure completely.

7.2 Preparing the mechanics for mounting the tail boom

Screw the tail boom flange 1292.5 to the bearing holder 4448.14 on the mechanics using two M3 x 16 socket-head cap screws. Press the M3 x 12 socket-head cap screw and M3 nut into the tail boom clamp, and tighten the screw fully to cut the threads. Loosen the screw again to the point where the tail boom can be pushed into place later.



7.3 Preparing the tail boom *(bag SR-2)*

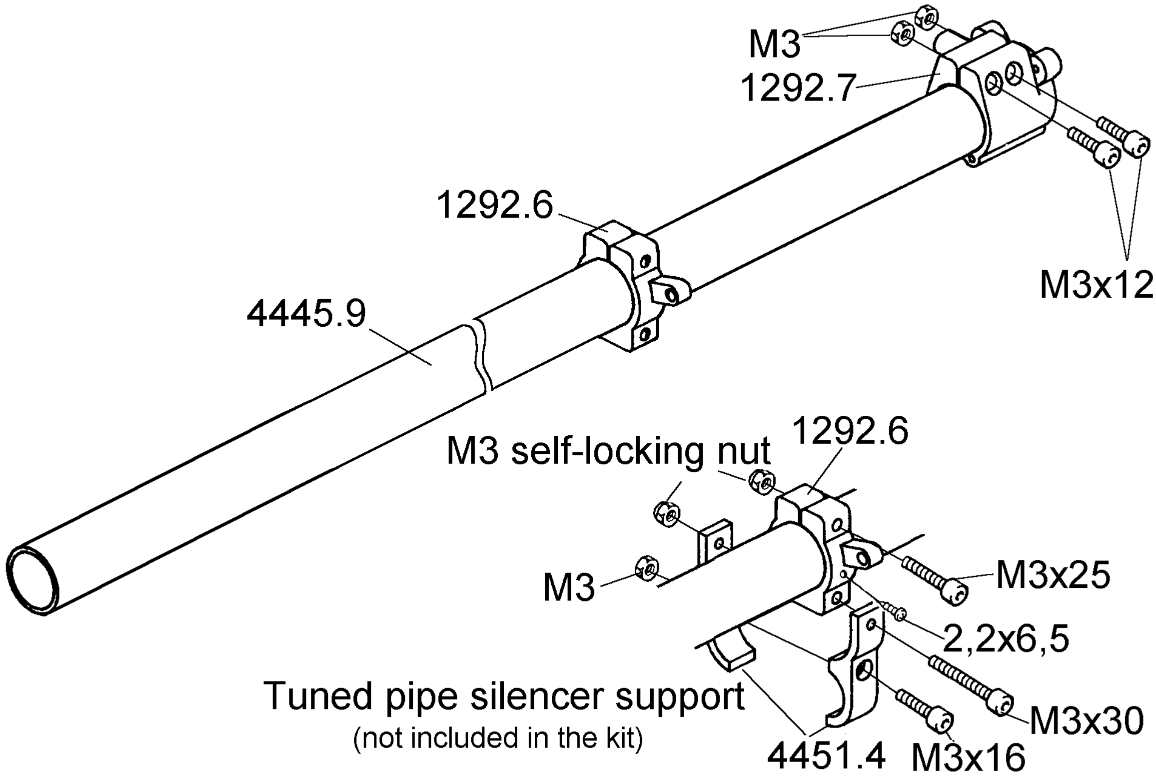
Note that the tail boom is curved *at the front end*; the purpose of the curvature is to raise the tail boom towards the tail. This increases tail rotor ground clearance, but - importantly - also ensures that the tail rotor drive shaft runs in a gentle curve, and thereby runs smoothly, without vibrating.

Push the two shaft bearings 1292.10A into the tail boom 4445.9 using a length of beech dowel or similar. The front bearing should be located 200 mm from the front end of the boom, and the rear bearing 300 mm from the rear end. The spherical recess in both bearings should face forward. Now place the guide ring 4451.7 in the front end of the tail boom, with the conical opening facing the rear, and set it at a depth of exactly 27 mm. When the tail drive system is connected, the union sleeve is guided accurately onto the coupling yoke by means of the guide ring.

The front shaft coupling can now be prepared; you must work carefully here, as the coupling must engage automatically inside the tail boom without you being able to see what is happening, and without using tools. For this reason it is important that the brass coupling sleeve 4618.58 is an easy sliding fit over the coupling yoke 4618.57. If necessary, remove any rough edges from the yoke, or reduce it in size slightly using fine abrasive paper. Slide the tail rotor drive shaft, Order No. 4451.19, into the coupling sleeve, and push it fully forward so that the pre-formed part engages inside the sleeve. Fit a grubscrew in the collet 56.0, slide it along the tail rotor shaft and position it just aft of the sleeve. Push the tail rotor shaft into the coupling yoke as far as it will go, then slide the sleeve over the yoke to the same extent. Position the collet on the shaft with about 1 mm clearance to the sleeve, and tighten the grubscrew fully.

7.4 Completing the tail boom

Fit the tail rotor flange 1292.7 on the rear end of the tail boom, then slide a support flange 1292.6 along the boom as shown in the drawing. Note that the gap in the support flange must be on top, and the moulded-in bored lug must be on the left-hand side.



If you intend to use a tuned pipe silencer, you will need to install an additional support for it on the tail boom, forward of the tail boom brace flange, as shown in the drawing. The parts for this are not included in the kit, and must be purchased separately.

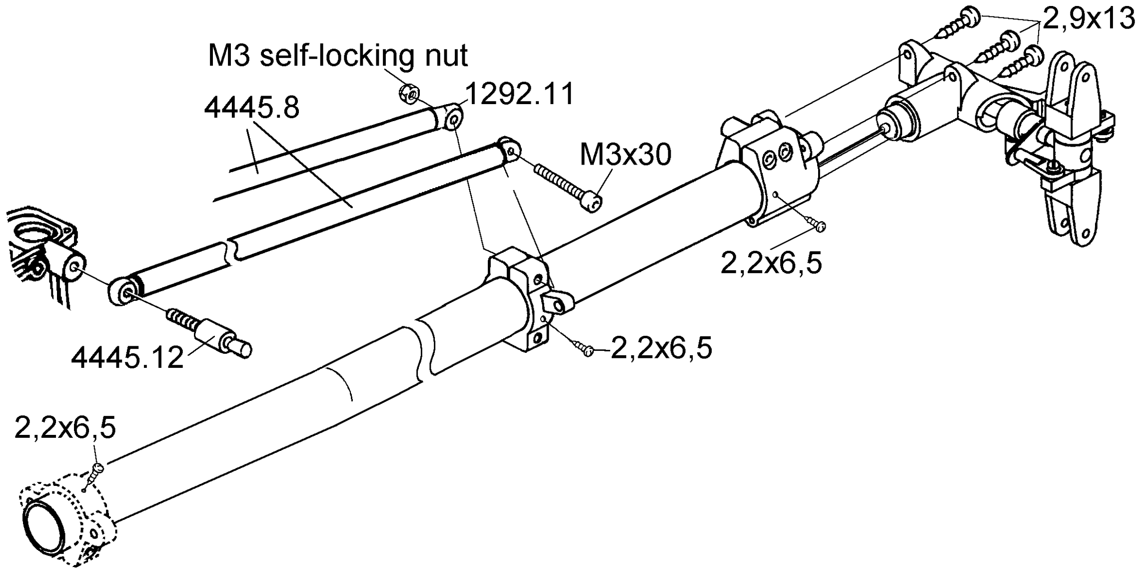
7.5 Determining the correct length of the tail rotor drive shaft

Remove the tail rotor drive shaft from the mechanics, oil it lightly, and slide it through the shaft bearings in the tail boom, rotating it all the while, until the rear end projects out of the tail boom far enough to be inserted in the tail rotor coupling. Push the shaft in as far as it will go, then pull it back again by 1 mm, and temporarily tighten the grubscrews in the coupling to secure it in this position. When finally assembled, the tail rotor shaft must have about 1 mm axial play in the front coupling yoke, and that is why you are temporarily setting up 1 mm clearance at the tail end. Later you will push the shaft into the tail rotor coupling as far as it will go, and the clearance will appear at the front end. Temporarily insert the tail boom in the tail boom flange 1292.5, at the same time pushing the tail boom fully onto the bearing holder 4448.14. Secure the tail boom by tightening the clamping screw in the flange. Slide the tail rotor into the tail boom from the rear, and rotate the shaft to ensure that the front end engages in the quick-release coupling which is part of the main gearbox. It should be possible to slide the tail rotor into the tail boom to the point where it rests against the flange, without the drive shaft fouling the quick-release coupling at the front. If this is not the case, the tail rotor shaft must be shortened slightly.

Alternatively you could re-position the tail rotor gearbox flange 1292.7 slightly further aft on the tail boom. Remove the tail boom from the mechanics again.

7.6 Connecting the tail boom to the mechanics

Withdraw the tail rotor assembly from the tail boom to the point where the shaft coupling becomes accessible. Undo the grubscrews in the shaft coupling, so that the tail rotor shaft 4451.19 can be pulled out. Carefully de-grease the shaft, push it as far as it will go into the shaft coupling, and secure it in this position with the grubscrews. This joint must be really firm. First unscrew the grubscrews from the coupling entirely, apply thread-lock fluid, Order No. 952, or bearing retainer fluid, Order No. 951, to the threaded holes, then re-fit the grubscrews and tighten them fully. Even better, file or grind a flat in one side of the shaft where the grubscrews engage, as this effectively prevents the shaft slipping in the joint. Fix the tail rotor to the tail rotor gearbox flange 1292.7 securely using three 2.9 x 13 mm self-tapping screws. Lightly grease the quick-release sleeve and the front end of the tail rotor shaft.
Attach the two tail boom braces to the left and right mechanics side frames using the stand-off pillars 4445.12, which you prepared in Section 7.1.



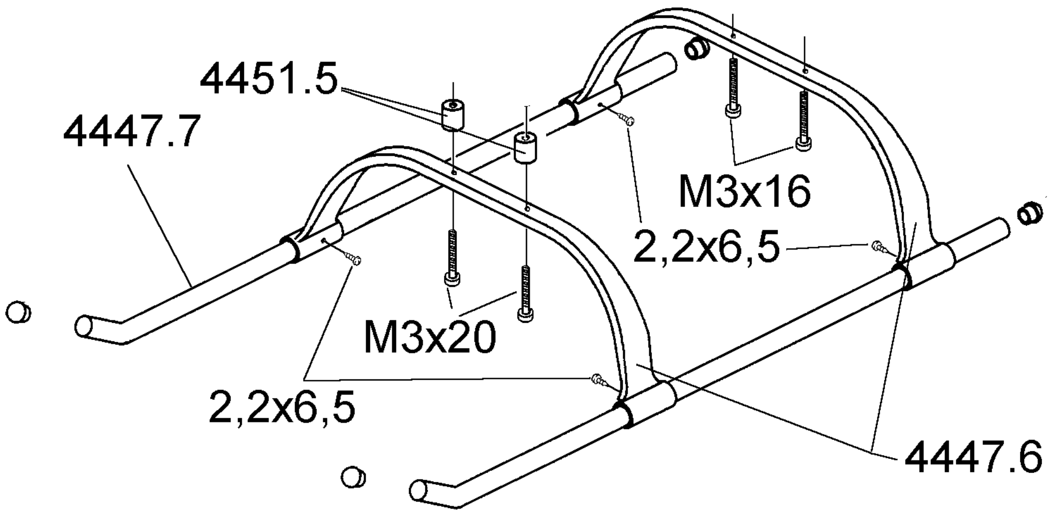
The completed tail boom assembly can now be pushed into the tail boom flange 1292.5 as far as it will go; check carefully that the quick-release coupling engages correctly. Rotate the tail boom so that the curve of the boom runs upwards, and is exactly in the vertical plane, and rotate the tail rotor flange so that the tail rotor shaft, when viewed from the tail, stands at right-angles to the main rotor shaft. With the tail boom correctly aligned, tighten the M3 x 12 socket-head cap screw in the tail boom flange to fix it in position. We recommend that you hold the tail boom pointing vertically upwards while you tighten the clamping screw.
Adjust the position of the rear flange 1292.6 so that the tail boom braces 4445.8 can be attached to it as shown in the drawing, using an M3 x 30 socket-head cap screw and an M3 self-locking nut.
Place the mechanical assembly on a perfectly flat table top, and adjust the position of the tail boom brace flange until the bottom edge of the tail rotor flange 1292.7 is about 170 mm above the surface of the table. In this position tighten the flange clamp securely, then drill 1.5 mm Ø pilot-holes in the tail boom through the tail rotor flange 1292.7, the tail boom brace flange 1292.6 and the tail boom flange 1292.5. Fit the 2.2 x 6.5 mm self-tapping screws to prevent the tail boom rotating or shifting position.

7.7 Stabiliser panels *(bag SR-3)*

Fix the vertical stabiliser 1292.4 to the tail rotor flange using 2.9 x 13 mm self-tapping screws. Attach the horizontal stabiliser to the tail boom by means of the stabiliser mount and the rod guide, using 2.9 x 19 mm self-tapping screws. Set the horizontal stabiliser exactly at right-angles to the vertical stabiliser; the distance between the horizontal stabiliser mount and the tail rotor flange should be 200 mm. Tighten the retaining screws.

8. Assembling the skid landing gear *(bag SR-4)*

Push the skid tubes 4447.7 through the skid bars 4447.6, and set the bars 207 mm apart (distance between retaining screws) by adjusting the position of the bars on the tubes.



The skid landing gear can now be fixed to the mechanics using two M3 x 16 socket-head cap screws at the rear and two M3 x 20 socket-head cap screws at the front; note that the spacer sleeves 4451.5 must be fitted at the front. Position the skid tubes so that they project beyond the rear skid bars by about 50 mm on both sides at the rear. Check that the skid tubes are parallel to each other. Working from the inside, drill 1.5 mm Ø pilot-holes through the skid bars and skids, and fit 2.2 x 6.5 mm self-tapping screws to fix the parts together. Apply a little two-pack adhesive to the end-plugs and press them into the skid tubes.

9. Installing the silencer

If you are using an expansion silencer, such as Order No. 1809.33 or 1871.72, install a pressure nipple in the expansion chamber and attach the silencer to the motor using the screws supplied with the unit. Don't use a gasket at the exhaust joint; it is better to apply a thin coating of thread-lock fluid to the contact surfaces.

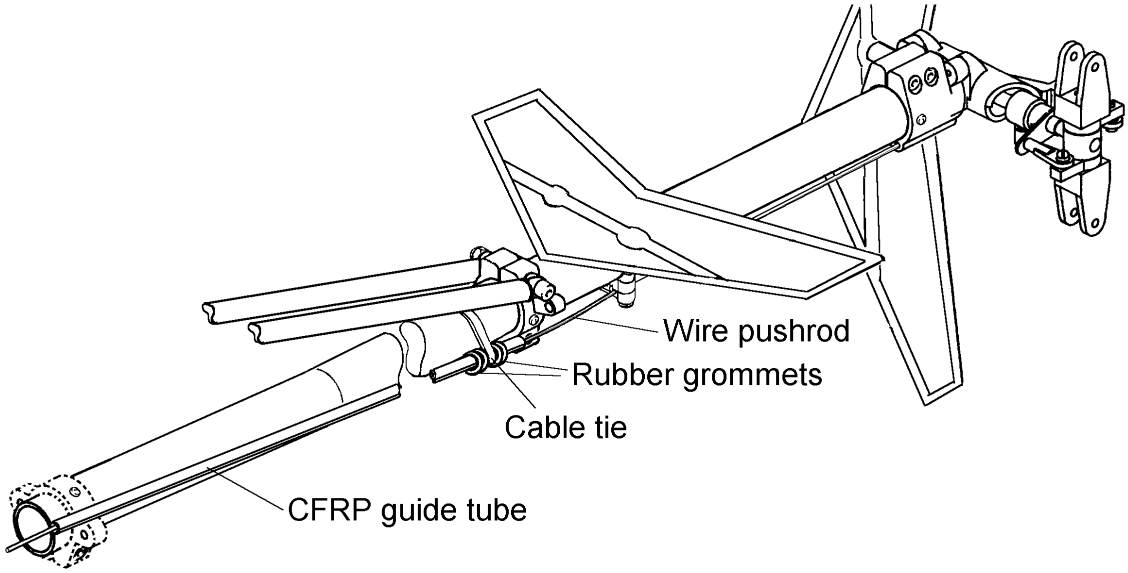
If you are using a tuned pipe silencer, for example Order No. 1783A, the first step is to screw the exhaust manifold 2259 to the motor, and pass it through the circular opening in the mechanics sub-structure; here again, a thin coating of thread-lock fluid is better than an exhaust gasket. Install a pressure nipple on the tuned pipe, then route the pipe through the rear bulkhead 4450.18, working from the rear, and connect it to the exhaust manifold with Teflon hose and spring clips; there should be a gap of about 5 mm between the manifold and the inlet stub of the tuned pipe. At an earlier stage you should have fitted the additional tail boom flange 1292.6, and this includes the tuned pipe support. Adjust the position of the support and rotate it so that the tail pipe of the tuned pipe silencer can be clamped in the holder by tightening the M3 x 16 socket-head cap screw. Fit a piece of silicone exhaust hose on the tail pipe before you do this.

Regardless of the type of silencer you are using, the pressure nipple on the silencer should be connected to the vent nipple which is mounted in the top of the fuel tank, using a length of silicone fuel tubing.

10. Tail rotor control system *(bag SR-5)*

The first step in connecting the tail rotor pushrod 4451.3 is to undo the screw in the tail rotor bellcrank 4618.60, and fit the straight end of the pushrod through the guide holes in the tail rotor gearbox flange and the horizontal stabiliser mount, working from the tail end. If the pushrod is a slightly tight fit in the tail rotor gearbox flange, open up the hole in the flange using a 2 - 2.5 mm Ø twist drill. Connect the pre-formed end of the pushrod to the outermost hole in the bellcrank, then fit the crank again and tighten the retaining screw.

Slide two rubber grommets onto the CFRP guide tube at the rear end to a distance of about 20 mm, and space them about 3 mm apart. Slip the guide tube onto the pushrod from the front, and position it so that it rests on the tail boom brace flange 1292.6 at the rear. Fix it in this position by wrapping a cable tie round the tail boom between the rubber grommets.

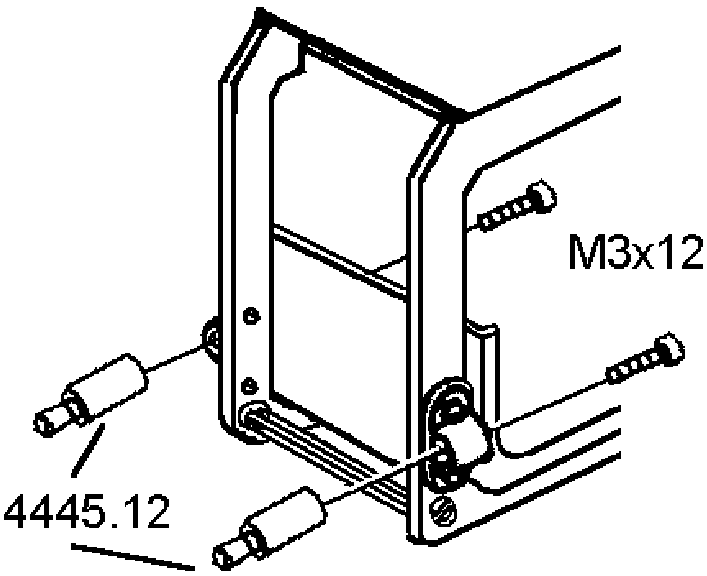


The front end of the guide tube must *not* be supported against the tail boom, but should be left „floating" freely on the wire pushrod; for this reason it must be left as long as possible, i.e. it should extend forward as close to the servo as possible.
At the front end the standard method of connecting the wire pushrod to the tail rotor servo is to solder a threaded coupler to the end, and screw a clevis on the coupler. Remember to cut the pushrod to the correct length before soldering the threaded coupler to the wire: when the collective pitch stick is at centre, the output arm of the tail rotor servo should point straight down, and the tail rotor bellcrank should be exactly at right-angles to the tail boom.
Alternatively you can simply form a Z-bend in the front end of the wire pushrod using Z-bend pliers (Order No. 5732). The advantage of this method is that the guide tube can be extended very close to the servo, providing maximum support for the pushrod, whereas it would have to be shortened further if a clevis and threaded coupler were used. The drawback is that you would have to determine the position of the Z-bend with great accuracy, because there is no means of adjusting the pushrod length with this arrangement. This solution is therefore only recommended to the experienced modeller.

11. Cabin *(bag SR-6)*

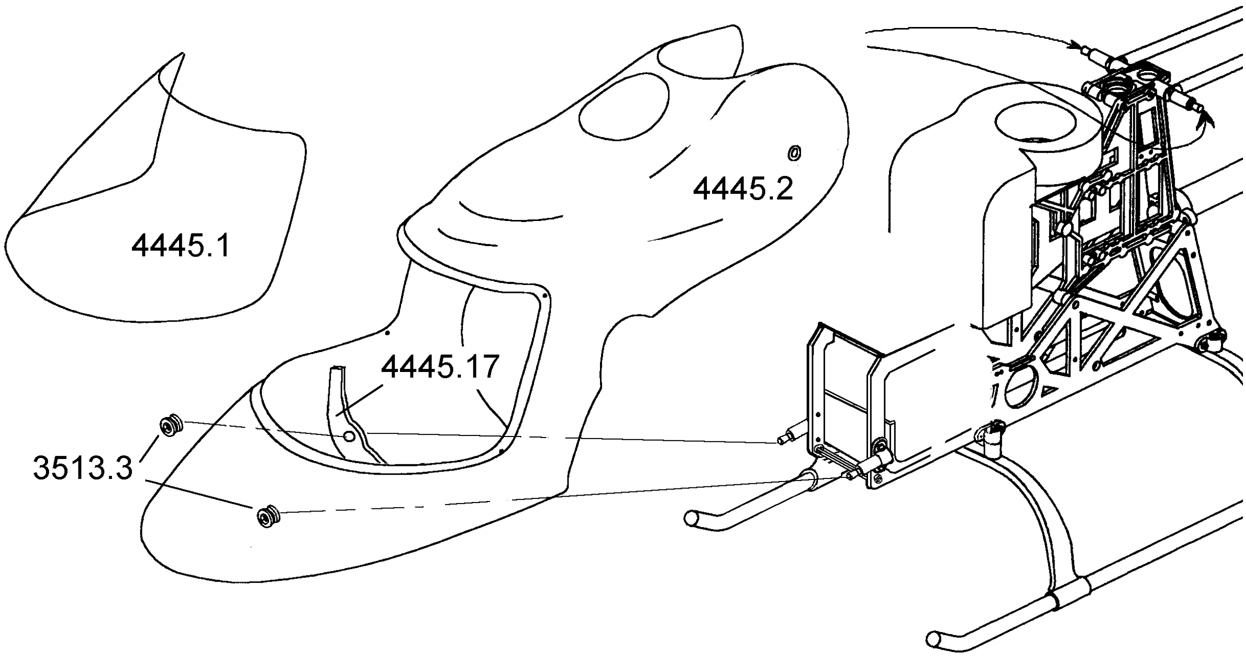
11.1 Installing the front cabin supports

Install the two front canopy stand-off pillars in the clips at the front of the sub-structure, securing each with an M3 x 12 socket-head cap screw fitted from the rear.



11.2 Attaching the cabin

Press two rubber grommets 3515.3 into the appropriate holes in the bulkhead 4445.17; you may like to apply a drop of cyano on one side to secure them. Fit the bulkhead, with the curved edge facing down, onto the stand-off pillars which are located on the front of the mechanics. The pillars should engage fully in the rubber grommets.
Fit two further rubber grommets in the 7 mm Ø holes in the top rear section of the cabin moulding. Slide the cabin onto the mechanics from the front, and engage the two stand-off pillars at top rear in the rubber grommets in the cabin moulding.
Swing the cabin up from the front until the bulkhead fitted to the front of the mechanics makes contact with the bottom of the cabin. You will need to cut away the cabin shell on the left-hand side to clear the exhaust manifold; there should be a gap at least 5 mm wide between cabin and exhaust system. The bulkhead can now be glued to the cabin in this position using Stabilit express. Allow the glue to cure fully before removing the cabin from the mechanics. It should come off easily by first pulling it off the rear stand-off pillars at the sides, and then pulling it forward. It should be equally easy to fit the cabin back on the model.

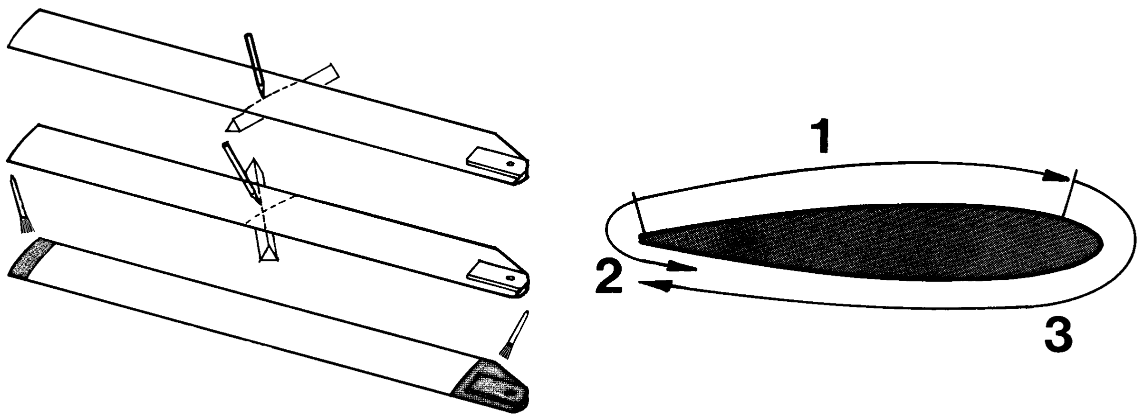


Tape the clear canopy screen 4445.1 to the cabin, then attach it using four 2.2 x 6.5 mm self-tapping screws. Alternatively you can glue it in place using cyano or Stabilit express. Work carefully if you use glue to avoid smearing the clear panel.

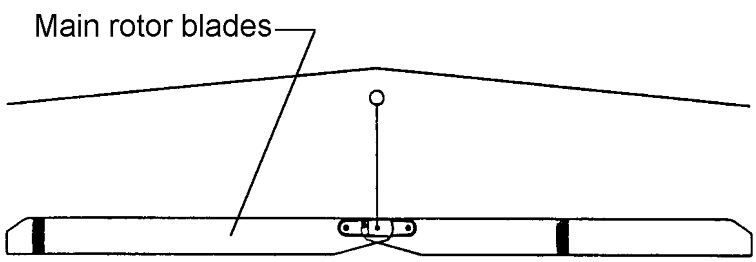
Run the receiver aerial along the mechanics to a point aft of the front skid bar, to ensure that the cabin can be removed easily without snagging the wire aerial. Fit the plastic aerial guide tube through the two holes on the inside of the skid bars, and fit short lengths of fuel tubing to prevent it slipping out. Run the aerial wire down the skid bar and into the front end of the guide tube, and allow it to dangle freely from the rear end of the tube.

12. Main rotor blades

Epoxy the rotor blade bushes 4607.164 in the root holes in the rotor blades, unless your blades are supplied with these parts factory-fitted.
Allow the epoxy to set hard, then sand the blades smooth overall using fine abrasive paper, Order No. 700.1 or 700.2.
Ideally both the weight and the Centre of Gravity of both blades should be identical. You can check this by balancing each blade over a triangular strip of wood, as shown in the drawing. Mark the lines of balance as shown; the blade's CG is located where the lines cross.
However, in practice it is unlikely that you will be able to achieve perfect balance and weight distribution without a considerable amount of work, and in any case it is not that important with modern model helicopters. The crucial factor is that the moments of both rotor blades should be the same when they are mounted on the rotor head. This means that blades of different weights can certainly be used, provided that the CG of the blades is also different, and compensates for the weight discrepancy. The method of balancing the blades is described in the next section.
Apply SPANNFIX IMMUN (colour dope), Order No. 1408, over the joints, in the region of the root doublers (approx. 70 mm from the root) and at the tip (approx. 20 mm from the tip). The film covering should be applied in the sequence shown in the drawing: first the top surface, then the trailing edge, then the underside. Take care with the covering; there should be no wrinkles or bubbles!



12.1 Balancing the rotor blades



Screw the two rotor blades together as shown in the drawing, and hang this assembly from a length of thread. Apply adhesive tape to the tip of the lighter blade until the blades hang level. Properly balanced blades reduce vibration to a minimum, so take your time over balancing.

13. The set-up procedure

13.1 Setting up the cyclic control system

The basic settings for the roll-axis and pitch-axis control systems should already be correct if you have installed the linkages exactly as described in the instructions. Since the instructions include the lever lengths (correct linkage holes), the final setting up is carried out using the electronic facilities on your transmitter. Note that the servo travel should not be set too high, and ensure that the swashplate does not strike its end-stops on the main rotor shaft at either end-point of the transmitter stick travel for roll-axis and pitch-axis movements, as this would mean that collective pitch control would not be linear, i.e. axial movements would be restricted.

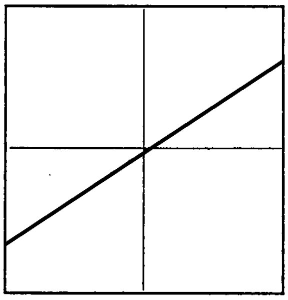
13.2 Main rotor pitch settings

The main rotor pitch is measured using a pitch gauge (optional accessory, not included in the kit). The following table shows the recommended basic settings, but the optimum values may well vary from model to model according to the rotor blades you are using.

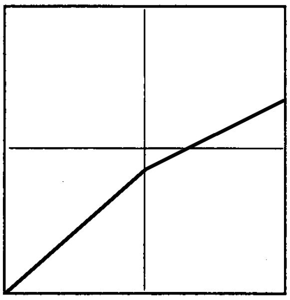
	Minimum	Hover	Maximum
Hovering and practice	-2°	5,5°...6°	12°
Aerobatics	-4°	5°... 5,5°	8°... 9°
Autorotation	-4°	5,5°	13°

The best way of setting the correct blade pitch on the transmitter is as follows:

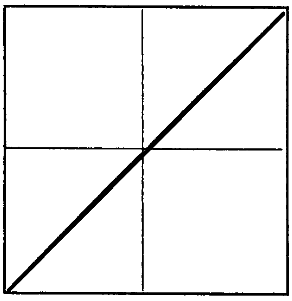
1. Measure the hovering pitch and set it to the correct value.
2. Measure collective pitch maximum and minimum and adjust the values according to the following diagrams using your transmitter's collective pitch curve facility.



Hover and practice
(linear)



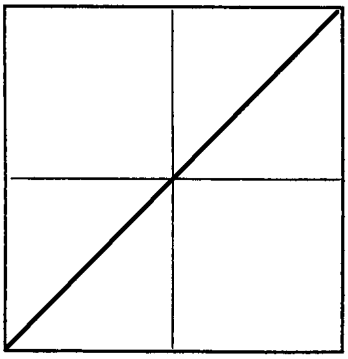
Aerobatics



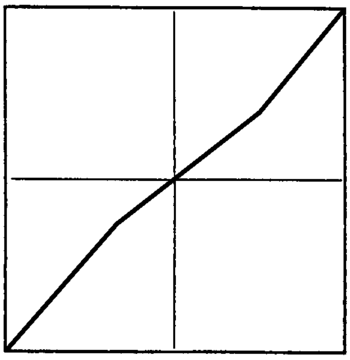
Autorotation

13.3 Setting up the carburettor control system

The following diagrams show two alternative carburettor control curves:



linear

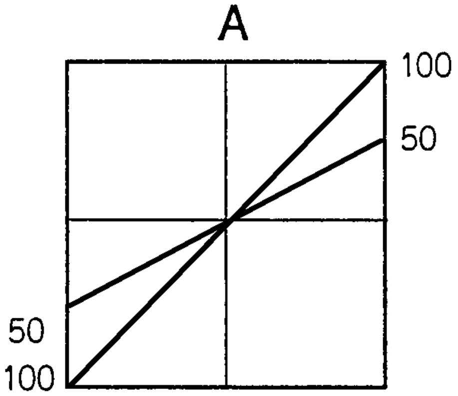


optimised for hover

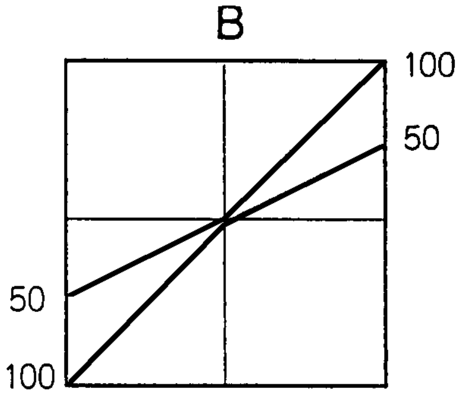
- The hover-optimised throttle curve produces gentle control response in the hover region.
- The values stated above can only be a guideline as they vary greatly according to the motor, fuel, silencer etc. in use. There is no alternative but to fine-tune them during the test-flying programme.

If you have made up all the linkages exactly as described in the previous sections, no changes to the mechanical arrangements will be necessary. The following adjustments can all be carried out at the transmitter:

1. **Servo direction**
   Set the „sense" (direction of rotation) of all servos as stated in the instructions. Check the throttle servo in particular!
2. **Dual-Rates**
   You can set switchable travels for roll-axis, pitch-axis and tail rotor. As a starting point we recommend 100% and 75% as the two settings.
3. **Exponential**
   For the basic set-up you should leave all control systems set to „linear".
4. **Servo centre offset**
   Do not make any adjustments to this point. At a later stage you may wish to make minor corrections here.
5. **Servo travel**
   This is where you can adjust the maximum servo travel. Note that the travels should always be the same on both sides of neutral, otherwise you will end up with unwanted differential effects:



Equal set values:
linear control response



Different set values:
differential control response

For the throttle and swashplate servos (collective pitch function) it is important to check that servo travels are symmetrical, i.e. identical values for both directions, and that the throttle servo can rotate the carburettor barrel from the completely closed position (motor stopped) to full throttle, without being mechanically stalled at any point. The collective pitch function of the swashplate servos should produce a range of blade pitch angles covering -5° to +13°, also with symmetrical travels; you may find it necessary to remove the servo output arm, move it round by one spline and fit the retaining screw again.

The mechanics should now be set up virtually perfectly. When the throttle/collective stick is at centre (hover point), collective pitch should be about 5.5°, and the carburettor barrel should be half-open.

Note:
The collective pitch and throttle curves can be adjusted later to meet your exact personal requirements. However, if you have already set differential travels in the basic set-up procedure, as shown in diagram „B" above, any fine adjustments required subsequently will be more difficult!

6. **Collective pitch and throttle curves**
   These adjustments are of fundamental importance to the flight performance of any model helicopter. The aim of the procedure is to maintain a constant rotor speed when the model is climbing and descending, i.e. regardless of load. This then represents a stable basis for further fine-tuning, e.g. of the torque compensation system etc. (see also the earlier section on collective pitch and throttle curves).
7. **Static torque compensation**
   The tail rotor servo is coupled to the collective pitch function via a mixer in the transmitter in order to compensate for torque changes when you operate the collective pitch control. On most transmitters the mixer input can be set separately for climb and descent. Recommended values for the basic settings are: climb: 35%, descent: 15%.

8. Gyro adjustment

Gyro systems damp out unwanted rotational movements around the vertical (yaw) axis of the model helicopter. They do this by detecting the unwanted motion and injecting a compensatory signal into the tail rotor control system, and in order to achieve this effect the gyro electronics are connected between the tail rotor servo and the receiver. Many gyro systems also allow you to set two different values for gyro gain, and switch between them from the transmitter via a supplementary channel. The extra channel is controlled by means of a proportional slider or rotary knob, or a switch, depending on the gyro system.

If your gyro features an adjustor box with two rotary pots for two fixed settings, and you can switch between them from the transmitter, it is best to set one adjustor approximately to centre (50%), and the other to 25%. If the gyro system provides proportional control between the two set values, then the one pot should be set to „0", the other to about 80%.

If you have a gyro system whose effect cannot be adjusted from the transmitter, i.e. there is only a single adjustor on the gyro electronics itself, the pot should be set to 50% gain as a starting point.

Check that the direction of the gyro's compensatory action is correct, i.e. that it responds to a movement of the tail boom with a tail rotor response in the opposite direction. If this is not the case, any yaw movement of the model would be amplified by the gyro! Most gyro systems are fitted with a change-over switch which reverses their direction, and this must then be moved to the appropriate position. However, some systems have no such switch, and in this case the solution is to mount the gyro inverted.

One factor which all gyro systems have in common is that flight testing is necessary in order to establish the optimum values, as so many different factors influence the settings.
The aim of the gyro adjustment process is to achieve as high a level of gyro stabilisation as possible, without the gyro causing the tail boom to oscillate.

Notes regarding the use of the Graupner/JR „PIEZO 900 ... 5000" piezo gyro system in conjunction with a computer radio control system (e.g. mc-12 ... mc-24)

The design of these gyro systems necessitates a different set-up process to the one described above. Please keep strictly to the following procedure:

1. Set the servo travel for the tail rotor channel to +/-100% at the transmitter.
2. If you have a gyro mixer („Gyro-Control") which suppresses the gyro when you operate the tail rotor control, it is essential to disable it permanently.
3. Disconnect the tail rotor pushrod at the tail rotor servo.
4. Operate the tail rotor control at the transmitter; at about 2/3 of full travel in either direction the servo should stop, even when the stick is moved further (travel limiter).
5. Connect the tail rotor pushrod to the servo in such a way that the mechanical end-stop of the tail rotor coincides with the onset of the limiter on both sides (servo should not quite be stalled by the mechanical end-stop).
   It is essential to make these adjustments mechanically, i.e. by altering the linkage points and pushrod length. Don't try to do it electronically using the transmitter's adjustment facilities!
6. Now correct the tail rotor setting for hovering, i.e. when the collective pitch stick is at centre, using the servo centre adjustment facility at the transmitter.
7. Gyro gain can now be adjusted between „0" and maximum via the auxiliary channel only, using a proportional control on the transmitter. If required, you can reduce maximum gain by adjusting the travel of the auxiliary channel or by adjusting the transmitter control (mc-22 and mc-24 transmitter). This gives you a useful range of fine adjustment for gyro response.
8. If you find that the tail rotor control system is too responsive for your taste, adjust it using the exponential control facility; on no account reduce servo travel, as it must be left at +/- 100%!

14. Final pre-flight checks

When you have completed the model, run through the final checks listed below before the first flight:

- Study the manual again and ensure that all the stages of assembly have been completed correctly.
- Check that all the screws in the ball-links and brackets are tightened fully after you have adjusted gear meshing clearance.
- Can all the servos move freely, without mechanical obstruction at any point? Do they all rotate in the correct direction relative to the stick movements? Are the servo output arm retaining screws fitted and properly tightened?
- Check the direction of effect of the gyro system.
- Ensure that the transmitter and receiver batteries are fully charged. We recommend using a voltage monitor module (e.g. Order No. 3138) to check the state of charge of the receiver battery on the flying field.

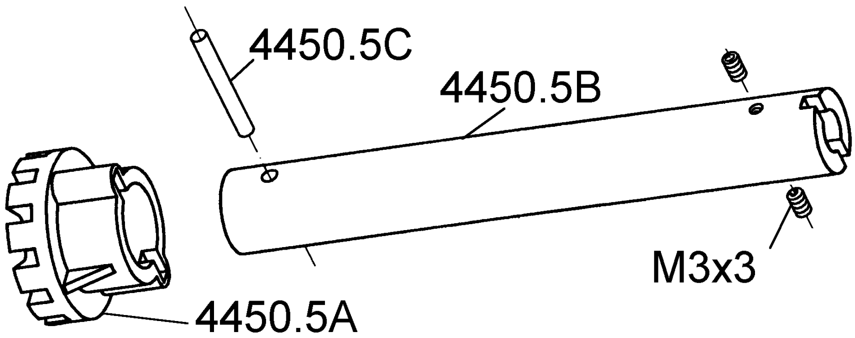
Don't attempt to start the motor and fly the helicopter until you have successfully checked everything as described above.
Bear in mind that the running qualities of your motor will vary greatly according to the fuel in use, the glowplug, the height of your flying site above sea level and atmospheric conditions. Please read the notes on motor set-up which you will find later in this manual.

Maintenance

Helicopters, whether large or small, place considerable demands on maintenance. Whenever you notice vibration in your model, take immediate steps to reduce or eliminate it. Rotating parts, important screwed joints, control linkages and linkage junctions should be checked before every flight. If repairs become necessary, be sure to use original replacement parts exclusively. Never attempt to repair damaged rotor blades; replace them with new ones.

Fitting the starter adaptor

The starter adaptor supplied with the mechanics consists of three parts which are assembled as shown in the drawing: first push the pin 4450.5C through the extension 4450.5B, then fit the plastic adaptor 4450.5A and check that the cross-pin engages in the channel in the moulding.
To mount the starter adaptor on the electric starter, first remove the rubber insert holder from the starter output shaft. Slide the starter adaptor onto the starter shaft until the cross-pin in the shaft engages with the channel in the adaptor. Tighten the two grubscrews to fix the adaptor in place.
Ensure that the adaptor runs „true“, i.e. does not wobble when it is spinning.

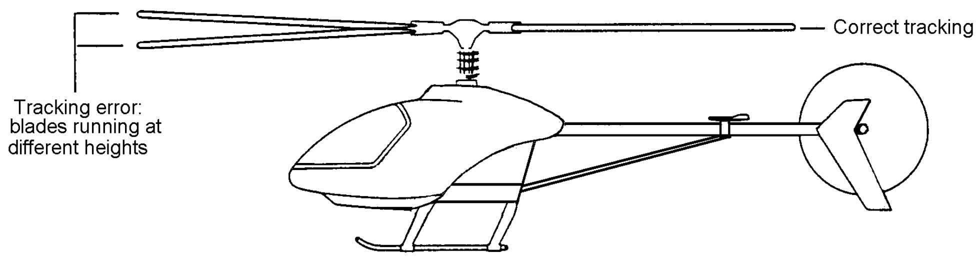


To start the motor, rotate the rotor head until you can engage the starter adaptor vertically in the motor's cooling fan. Please note:

- **Do not switch the starter on until you are sure that the teeth of the cooling fan are correctly engaged with the matching teeth on the starter adaptor.**
- **When the motor has started, switch off the starter before withdrawing it.**

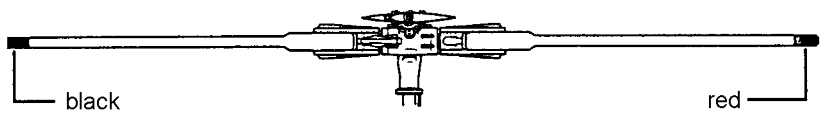
15. Adjustments during the first flight
15.1 Blade tracking
“Blade tracking" refers to the height of the two rotor blades when they are spinning. The adjustment procedure aims at fine-tuning the pitch of the main rotor blades to exactly the same value, so that the blades rotate at the same level.

Incorrectly set blade tracking, with the blades revolving at different heights, will cause the helicopter to vibrate badly in flight.

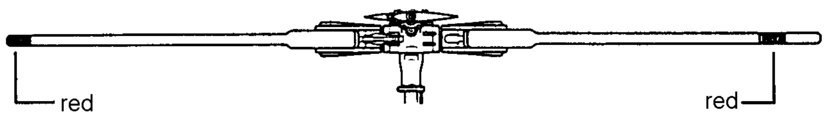


When you are adjusting blade tracking you are exactly in the „firing line" of the blades, so keep at least 5 metres away from the model in the interests of safety.

You can only check blade tracking if you are able to see clearly which blade is higher and which is lower. The best method is to mark the blades with coloured tape as follows:



A



B

There are two alternative methods: figure „A" shows the use of different colours on the blade tips; fig. „B" shows the use of the same colour, but applied at different distances from the blade tip.

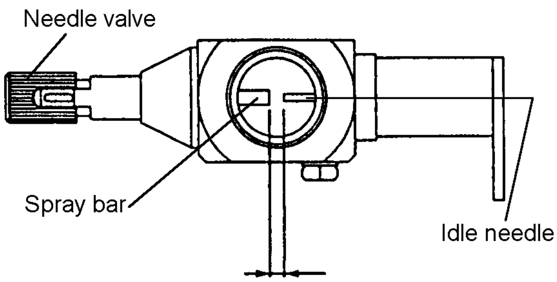
Procedure for adjusting blade tracking:

1. Set the helicopter to the point where it is almost lifting off, then sight directly along the rotor plane.
2. If you can see that the rotor blades are running in the same plane, no adjustment is required; however, if one blade is running higher than the other, the settings must be corrected.
3. Locate the pushrods between the swashplate and the mixer levers; the adjustment is made at the ball-links on both ends of these pushrods: unscrew the links to raise the blade, screw them in to lower it.

15.2 Adjusting the motor

Please be sure to read the operating instructions supplied with your motor.

The correct matching of collective pitch and throttle when the helicopter is hovering is of crucial importance to the model's flying characteristics and performance. For example, if the pitch of the main rotor blades is too high, the motor may not reach the intended rotational speed, and this may cause you to think that the motor is not powerful enough for the job. The fact that the motor will overheat and thereby lose more power tends to reinforce that idea. For this reason first set the collective pitch value for the hover exactly as described earlier in these instructions, then match the motor settings to that.
Although most motors nowadays are supplied with the carburettor adjusted to approximately the right settings, final adjustment of the needle valves can only be made under practical test conditions. Most motors now feature twin-needle carburettors, and in this case the starting point for adjusting the idle / mid-range needle is to screw it in to the point where it just dips into the needle valve on the opposite side when the carburettor is half-open.



Typical twin-needle carburettor

For your first attempt at starting the motor, open the needle valve 1½ to 2 full turns from closed, connect the glowplug to the plug battery and start the motor by engaging the adaptor on the electric starter in the teeth of the fan and switching the starter on.

Caution: when the motor starts, withdraw the electric starter from the fan socket immediately, otherwise you could damage the model.

When the motor is running, slowly increase throttle/collective pitch. If the fuel mixture is too „rich" and the model fails to lift off, close (screw in) the needle valve in small stages. In order to set the motor correctly for hovering you will need to adjust the idle needle, which also governs the mid-range settings. Note that any adjustment you make here is also influenced by the primary needle valve setting. Carefully close (screw in) the idle needle until the motor runs smoothly at hover, without any tendency to stop through too rich a mixture. If motor speed is then too low, increase the hover throttle setting at the transmitter. Never attempt to increase the motor speed for hovering by setting the idle needle too lean. The final needle valve setting can only be established with the model flying under power with „full collective", and for this reason you are bound to start by „feeling your way" slowly to the correct setting.

If in any doubt, always set the mixture on the „rich" side. Initial hovering flights should always be carried out with the motor set distinctly rich.

16. General safety measures

- Make sure you have adequate third-party insurance cover.
- Wherever possible join the local model flying club.

At the flying site:

- Never fly your model above spectators.
- Do not fly models close to buildings or vehicles.
- Avoid flying over agricultural workers in neighbouring fields.
- Do not fly your model in the vicinity of railway lines, major roads or overhead cables.

Pre-flight checks, flying safety:

- Before you switch on the transmitter check carefully that no other model flyer is using the same frequency as you.
- Carry out a range check with your RC system.
- Check that the transmitter and receiver batteries are fully charged.
- Whenever the motor is running, take particular care that no item of clothing can get caught on the throttle stick.
- Do not let the model fly out of safe visual range.
- There should always be a safe reserve of fuel in the tank. Never keep flying until the fuel runs out.

Post-flight checks

- Clean oil residues and dirt from the model and check that all screws etc. are still tight.
- Look for wear and damage to the helicopter, and replace worn parts in good time.
- Ensure that the electronic components such as battery, receiver, gyro etc. are still securely fixed. Remember that rubber bands deteriorate with age and may fail.
- Check the receiver aerial. Conductor fractures inside the flex are often not visible from the outside.
- If the main rotor should touch the ground when spinning, replace the blades. Internal blade damage may not be visible from the outside.
- Never carry the model by the tail boom: too firm a grip can easily deform the tail rotor pushrod.

17. Some basic terms used in model helicopter flying

The term „rotary wing machine" indicates that the helicopter's lift is derived from rotating „wings" which take the form of rotor blades. As a result, a helicopter does not require a minimum forward speed in order to fly, i.e. it can hover.

Cyclic pitch
Cyclic pitch variation is used to steer the machine around the roll and pitch axes. Changing cyclic pitch has the effect of altering blade pitch depending on its position in the circle. The effect is caused by tilting the swashplate, which then effectively tilts the helicopter in the required direction.

Collective pitch
Collective pitch provides control over vertical movement, i.e. for climb and descent. The pitch of both rotor blades is altered simultaneously.

Torque compensation
The spinning rotor produces a moment which tends to turn the whole helicopter in the opposite direction. This effect must be accurately neutralised, and this is the task of the tail rotor. Tail rotor blade pitch is altered to vary torque compensation. The tail rotor is also used to control the model around the vertical (yaw) axis.

Hovering
This is the state in which the helicopter flies in a fixed position in the air, without moving in any direction.

Ground effect
This occurs only when the machine is close to the ground, and it falls off as altitude rises. At an altitude of about 1 - 1.5 times the rotor diameter, ground effect is completely absent. Normally the revolving airflow from the main rotor is able to flow away freely, but in ground effect the air strikes an obstacle (the ground) and forms an „air cushion". In ground effect a helicopter can lift a greater weight, but its positional stability is reduced, with the result that it tends to „break away" in an unpredictable direction.

Climb
Any excess power above that required for hovering can be exploited to make the helicopter climb. Note that a vertical climb requires more energy than an angled climb which includes forward motion. For this reason a model with a given amount of motor power will climb more rapidly at an angle than vertically.

Level flight
A helicopter absorbs least power when flying straight and level at about half-power. If you have trimmed the machine carefully for a steady hover, it will tend to turn to one side when flown forward. The reason for this phenomenon is that the rotor blade which is moving forward encounters an increased airflow caused by the wind, and this increases its upthrust compared with the blade which is moving downwind, where the same airflow has to be subtracted. The net result is a lateral inclination of the helicopter.

Descent
If the helicopter's rotor speed is relatively low and you place the helicopter in a fast vertical descent, the result can be that insufficient air flows through the rotor. This can cause what is known as a „turbulent ring", when the airflow over the blade airfoil breaks away. The helicopter is then uncontrollable and will usually crash. A high-speed descent is therefore only possible if the helicopter is moving forward, or if the rotor is spinning at high speed. For the same reason care should be exercised when turning the model helicopter downwind after flying into wind.

Flapping motion of the rotor blades
As we have already seen, the forward-moving blade produces greater upthrust than the trailing blade. This effect can be minimised by allowing the leading blade to rise and the trailing blade to fall. The rotor head is fitted with what is known as a flapping hinge to allow this movement, and this prevents the rotor plane tilting excessively in forward flight. In model helicopters a single hinge shared by both blades has proved an effective solution to the problem.

Auto-rotation
This term refers to the flight of a helicopter without motor power. The rotational speed of the main rotor can be kept high by setting both blades to negative pitch, and the airflow through the rotor as it descends then keeps the blades turning. The rotational energy stored in the rotor by this means can be converted into upthrust when the helicopter is close to the ground, by the pilot applying positive collective pitch. Of course, this can only be done once, and it has to be done at the correct moment. Auto-rotation allows a model helicopter to land safely when the motor fails, just like a full-size machine.

However, auto-rotation places considerable demands on the pilot's judgement and reflexes; you can only halt the machine's descent once, and you must not „flare" too early or too late. Much practice is required to get it right.