Graupner / heim

UNI-EXPERT mechanics

since '02 series

Order No. 4449.RXN
Mechanics, factory-assembled, with integral motor

Order No. 4450.L
Mechanics, unassembled, excluding motor

Warning!

The RC helicopter which can be built based on this mechanical system is by no means a toy! It is a complex flying machine which is capable of causing serious personal injury and damage to property if handled and operated incompetently.
You alone are responsible for completing the model correctly and operating it with due regard for safety. Please be sure to read and observe the enclosed sheets SHW3 and SHW7 which include full safety information. They should be considered as an integral part of these instructions.

GRAUPNER GmbH & Co. KG D-73230 KIRCHHEIM/TECK GERMANY
Änderungen und Druckfehler vorbehalten ID# 46287 8/02

Foreword

The Graupner/Heim UNI-EXPERT mechanics set is a self-supporting helicopter mechanics aggregate for 10 cc two-stroke motors.
In conjunction with a fuselage kit (available separately) the system produces a modern all-purpose model helicopter which is equally suitable for training, aerobatics and competition work.
Good accessibility to all components makes maintenance and repair work easy and trouble-free, both at the flying site and in the workshop.
The UNI-EXPERT mechanics can be completed with either a simple cabin and tubular tail boom to form a trainer for beginners and more advanced practice flying, or installed in any of a wide range of beautiful GRP fuselages. In every case the result is a model helicopter whose all-up weight is very low, and therefore possesses considerable reserves of performance. This is the result of the extensive exploitation of high-strength, vibration-absorbing glass fibre reinforced nylon. The excess performance can be utilised by the experienced pilot for power-sapping aerobatics, but it also provides ample reserves for the beginner who finds it difficult to set up his model exactly perfectly. The extra performance also copes effortlessly with additional features such as a training landing gear.

The Graupner/Heim UNI-EXPERT mechanics set offers the following outstanding design features:

- Mechanical construction based primarily on vibration-absorbing, fatigue-free, high-strength glass fibre reinforced nylon.
- Highly efficient two-stage main gearbox.
- Clutchshoe and Clutchbell mounted directly on the motor's special „HEIM" crankshaft for optimal lining of the clutch and very low vibrations.
- Good access to all vital components, making the system easy to repair and maintain.
- Servo installation immediately below the swashplate for rigid, direct, backlash-free control linkages. All mixing is carried out by the transmitter electronics, which results in accurate overall control response.
- High-efficiency cooling fan for the motor.
- "In-line" muffler arrangement in the bottom section of the mechanics makes the system ideal for slim fuselages, and suits rear-exhaust motors perfectly; however, side-exhaust motors can also be used.

Warnings

- The contents of this kit can be assembled to produce a working model, but the model is by no means a harmless plaything. If assembled 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 result in 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 - SHW3 and SHW7- 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 the 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 the 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 to ensure that you build and fly your new model helicopter safely and without problems. Whether you are a beginner or an expert, please be sure to follow these instructions, step by step, exactly as described in the text.

- Even if you bought a factory-assembled version of the mechanics set it is not set up or adjusted ready to fly. It is entirely the modeller's responsibility to check that all screws and other joints are tight and secure, and to carry out the essential adjustments thoroughly and conscientiously.

- The process of completing the mechanics is carried out by referring to the illustrations and the explanatory texts which accompany them.

- The joints marked with this symbol ▬▬ must be secured with thread-lock fluid, e.g. Order No. 952 resp. Order No. 951; be sure to remove all traces of grease 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.

- Parts list, replacement parts list and exploded drawings are included at the end of the instructions.

Accessories

Recommended motors and accessories for UNI-EXPERT mechanics

Motor	Capacity ccm	Order No.	Exhaust manifold	Compact silencer	Tuned pipe silencer
OS MAX 61 RX-HGL»C«	9,95	1892	2239A -	2258 2253	2240 or 2250
OS MAX 61 RX-HGL Sport	9,97	1918	2239A -	2258 2253	2240 or 2250

Main rotor blades, e.g.

Order No. 74A	Wood, symm. section	625mm long	Rotor-Ø 1425mm
Order No. 1246B	GRP, reflex section	688mm long	Rotor-Ø 1551mm
Order No. 1266	CRP, symm. section	686mm long	Rotor-Ø 1547mm

Glowplug battery, e.g.

Varta RSH 4	Order No. 1353	
2 V glowplug battery	Order No. 3694	) use only with dropping resistor,
2 V glowplug battery	Order No. 771	) Order No.1685 or 1694

Fuel

AeroSynth COMPETITION SX-10 Order No. 2811.5 (5 l) or Order No. 2811.10 (10 l)

Starter

Electric starter, Order No. 1628 or 1626. (12 V starter battery, Order No. 2593.)

Radio control equipment (see main Graupner catalogue)

A radio control system equipped with specialist helicopter options or a micro-computer RC system such as the mc-12, mc-14, mc-15, mc-16/20, mc-22 or mc-24 is required.
The minimum requirement on the RC system is that it has a 3-point swashplate mixer and five servos for the functions pitch-axis, roll, collective pitch, tail rotor and throttle.

RC functions

Swashplate, lateral:	roll function, right/left
Swashplate, longitudinal:	pitch-axis function, forward/back
Tail rotor:	Rotation around the vertical (yaw) axis
Throttle and collective pitch:	Rise and descent
Also recommended:	Gyro stabilisation of the tail rotor function
	Governor system for main rotor speed

Servos (we recommend high-performance servos) such as
C 4421, Order No. 3892

Gyro:

Gyro-System PIEZO 5000, Order No. 5146 with Super-Servo DS 8700 G, Order No. 5156 or Gyro-System PIEZO 550, Order No. 5147 or Gyro-System PIEZO 450, Order No. 5138

Electronic rotor speed governor:

mc-HELI-CONTROL, Order No. 3286

Receiver battery:

For safety reasons we recommend that you use a battery of at least 1800 mAh capacity and a switch harness with adequate wire sizes for the currents which can occur.
We recommend the POWER switch harness, Order No. 3050, with 4N-2000 RX battery, Order No. 2557.

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

We also advise the use of the NC-AKKU-CONTROLER, Order No. 3138, so that you can monitor the condition of the receiver battery at all times.

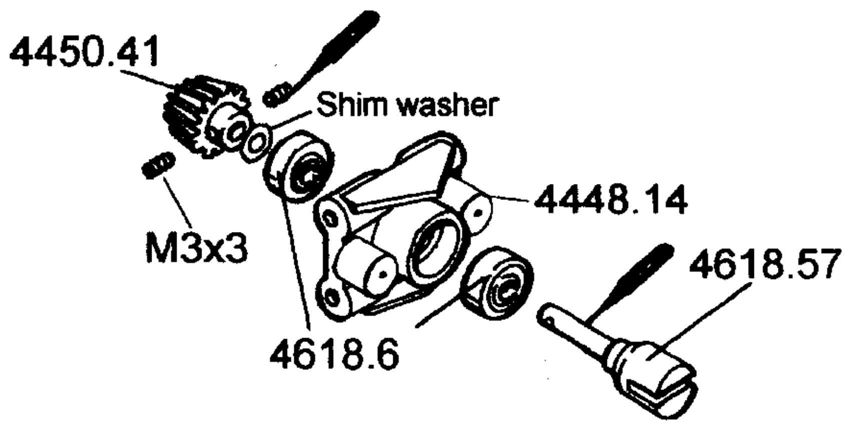
1. Assembling the main mechanics *(bag UM-1)*

The mechanical system of the UNI-EXPERT mechanics 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 are smashed into pieces, 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 UNI-EXPERT mechanics 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 model helicopters with metal frames.

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 UNI-EXPERT mechanics state which connections should be made using thread-lock fluid and/or bearing retainer fluid.

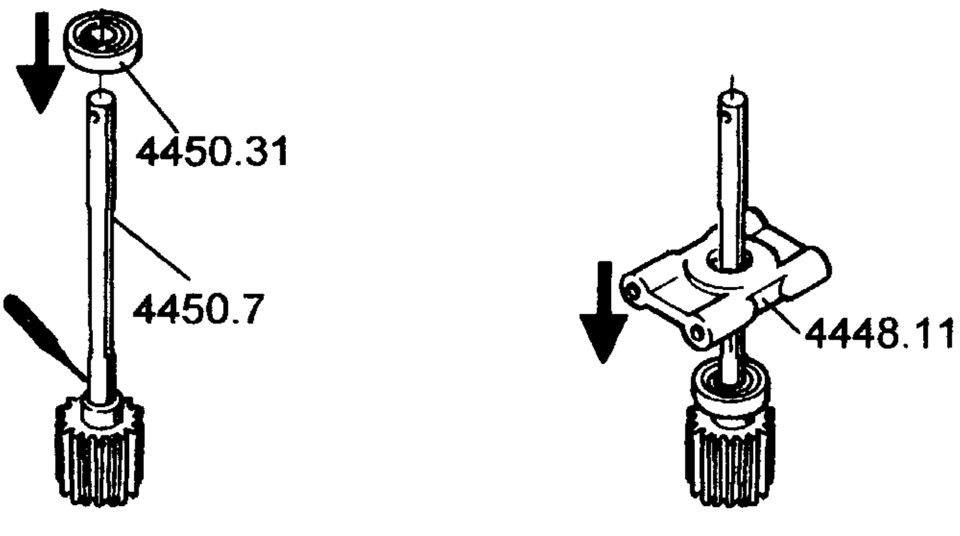
1.1 Assembling the tail rotor drive system *(bag UM-1A)*



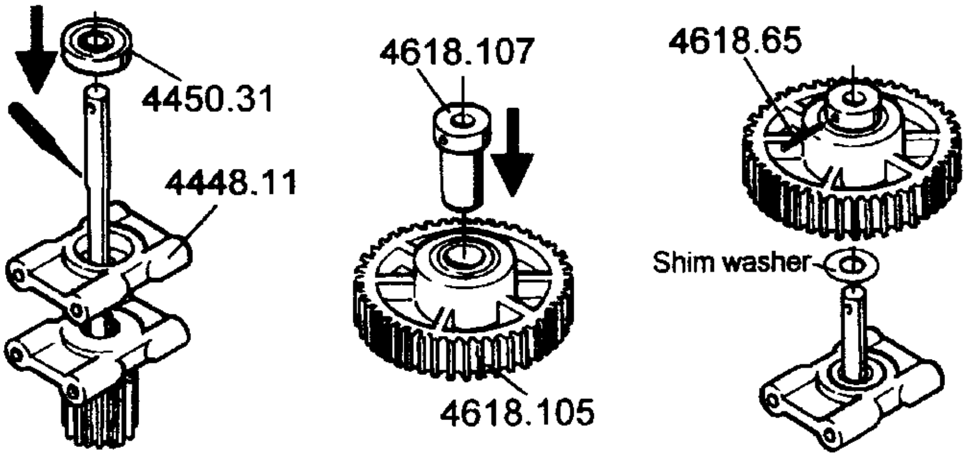
Please note that there must be no axial play at all in the quick-release coupling shaft 4618.57 when fitted in the bearings 4618.6. If the shaft does not seat securely enough in the bearings, fix it to the bearings using bearing retainer fluid 603, Order No. 951. This is the procedure: first fit the 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)*

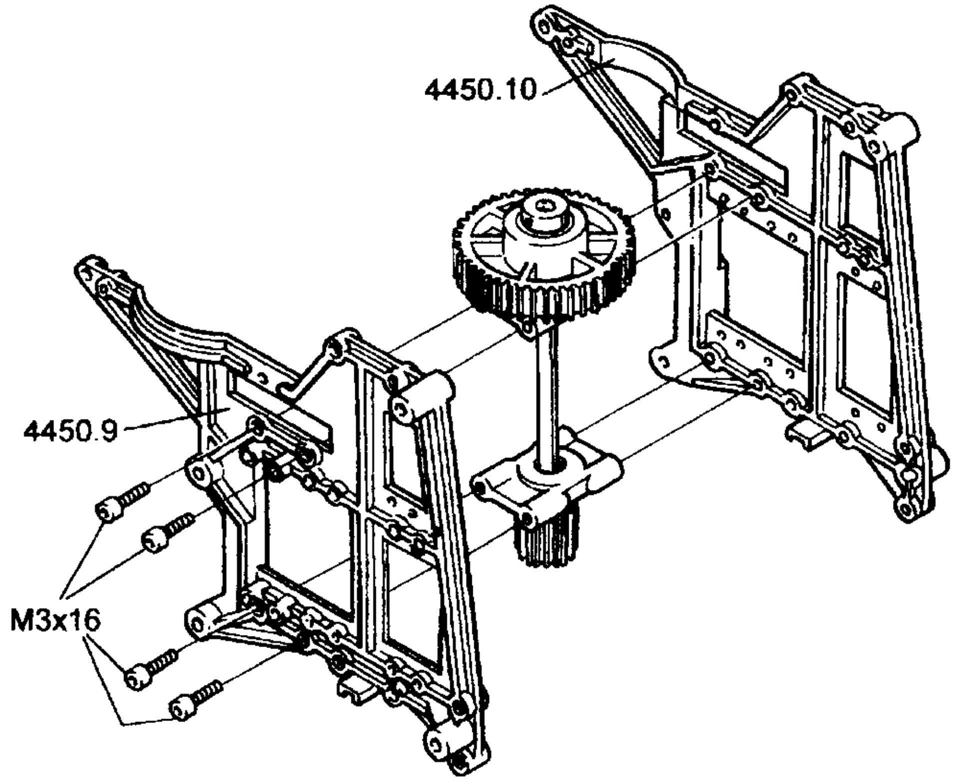
Fix the bottom bearing 4450.31 for the layshaft 4450.7 on the shaft, using bearing retainer fluid 603, Order No. 951. Position the bearing resting against the pinion, then leave the fluid to cure. Press the shaft and bearing into the bottom bearing support 4448.11.



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.



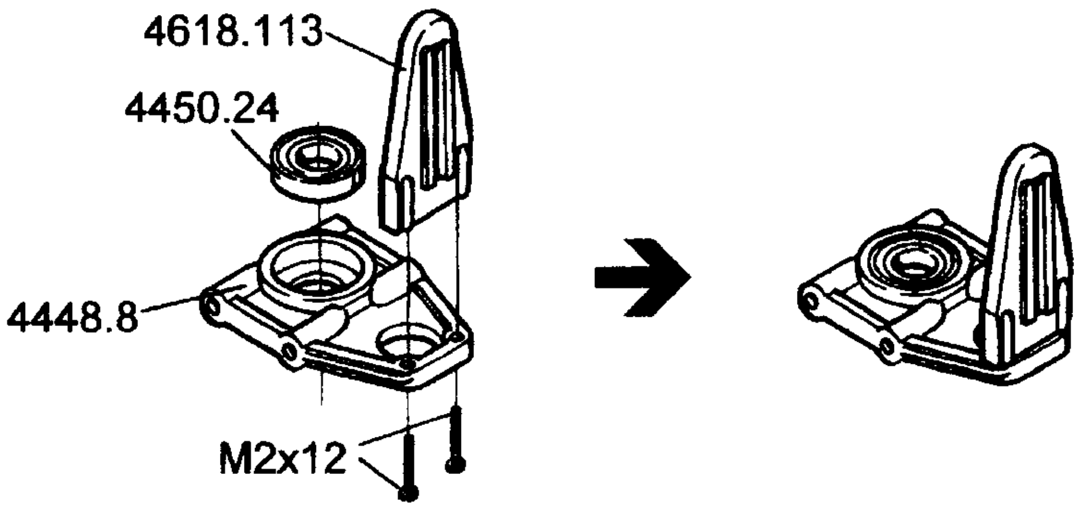
Now press the top bearing 4450.31 into the bearing support 4448.11 and push this assembly up against the shim washer under the freewheel sleeve. Take the layshaft assembly which you have assembled to this stage, and place it between the mechanics side frames 4450.9 and 4450.10, so that you can check 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.

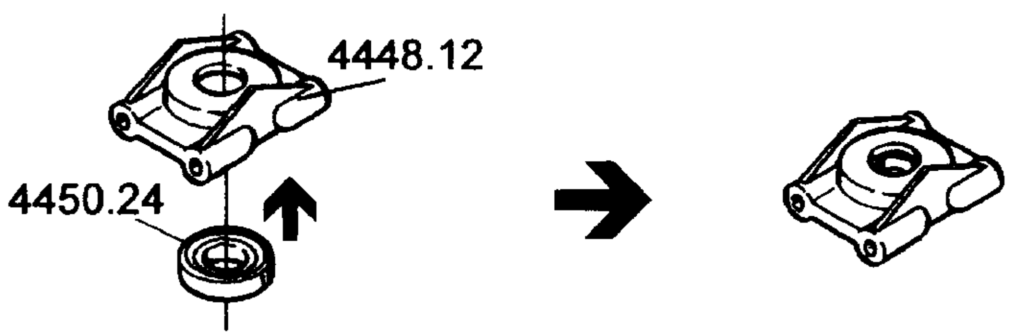


Once you are confident that the spacing is set correctly, glue the shaft to the bearing in the usual way using bearing retainer fluid, Order No. 951, but only after you have pressed the roll-pin into the freewheel sleeve fully and permanently. Fit this assembly between the mechanics side frames and tighten 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)*

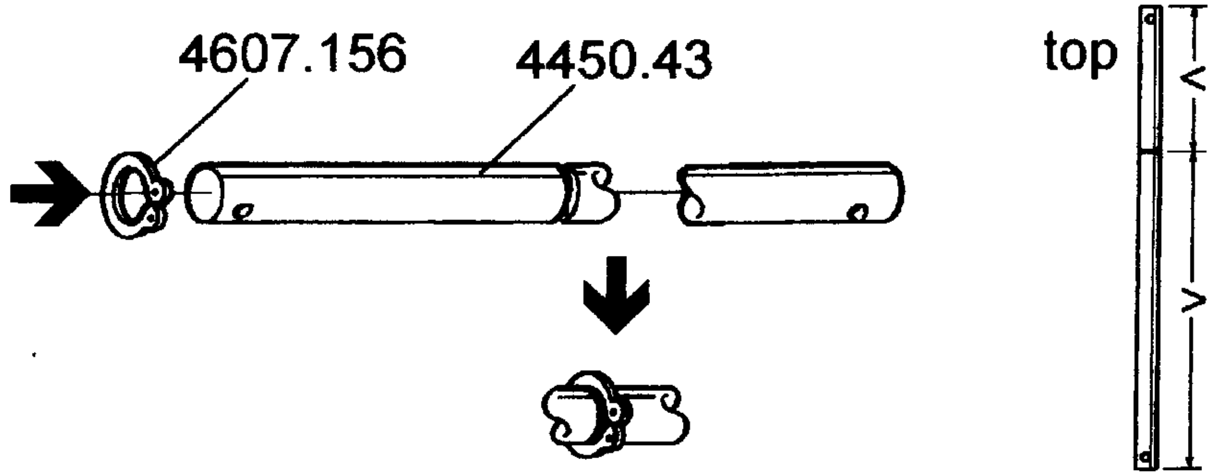
Fix the swashplate guide 4618.113 to the dome bearing holder 4448.8 using two M2 x 12 cheesehead screws. Press one of the ballraces 4450.24 into the dome bearing holder, and one into the main rotor shaft bearing holder 4448.12; grease both bearings.





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:

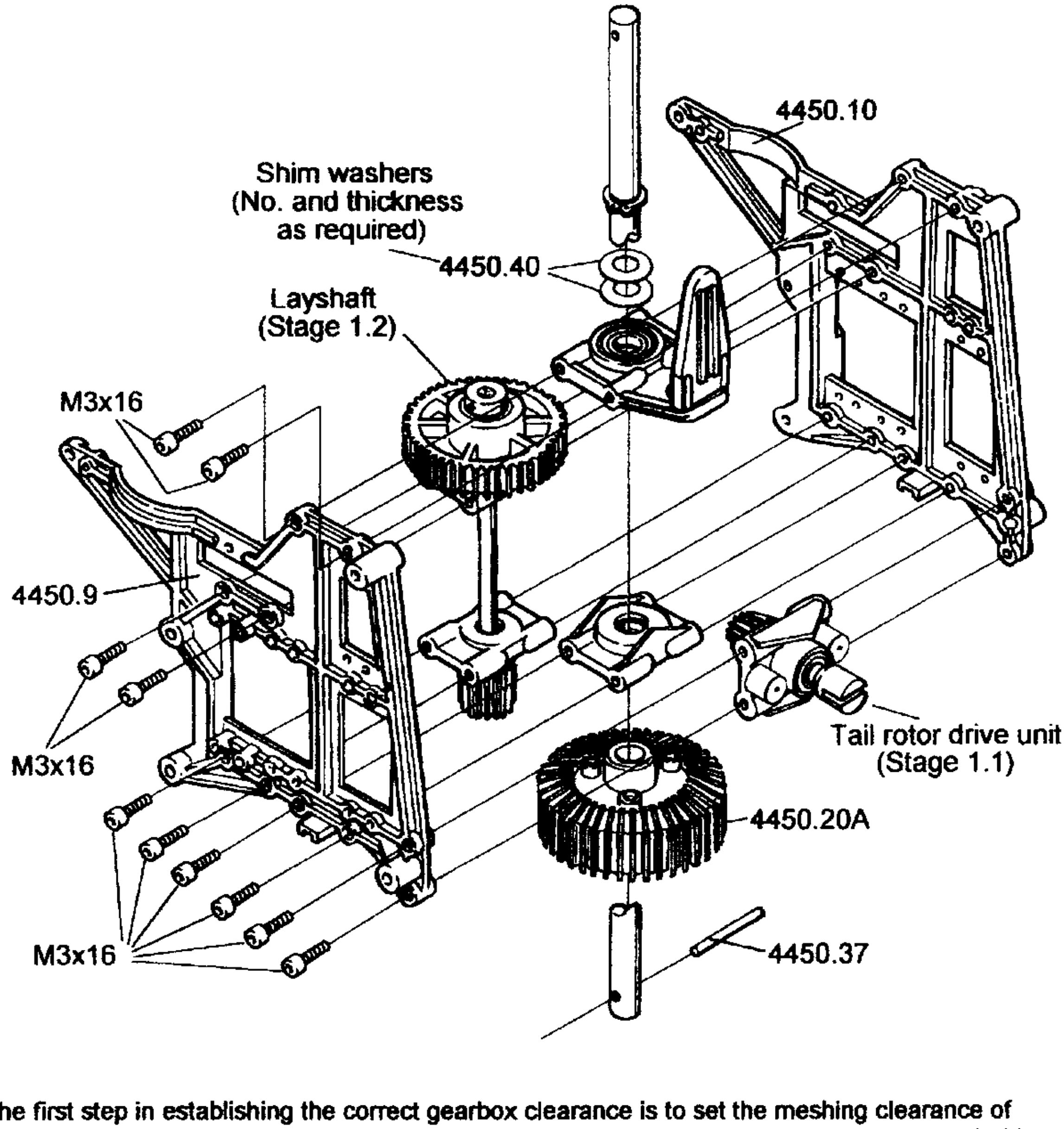
- The circlip must not be over-stressed, i.e. take care not to open it further than absolutely necessary in order to slide it onto the main rotor shaft. Special circlip pliers are the best tool for this job.
- The inner face of the circlip features one rounded and one sharp edge; the sharp side must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



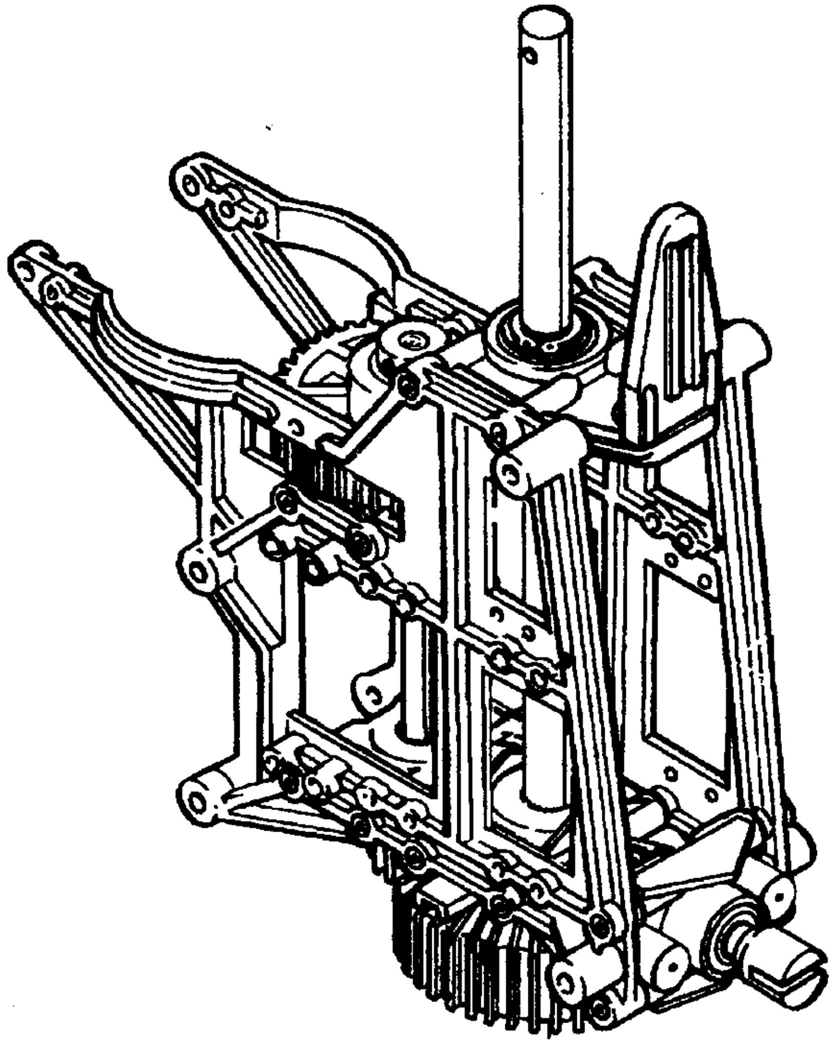
1.4 Assembling the main gearbox

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!



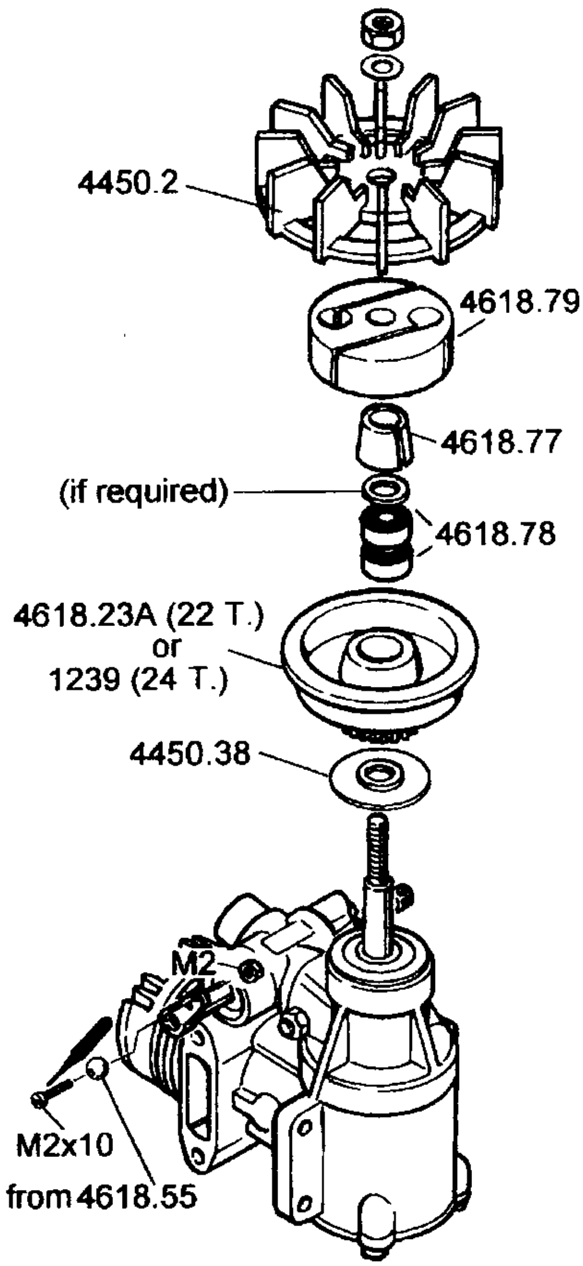
The first step in establishing the correct gearbox clearance is to set the meshing clearance of this gearbox stage slightly too tight, i.e. the gears should mesh „hard" against each other. If this is not the case, i.e. if there is already significant clearance between the gears after you have assembled 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.

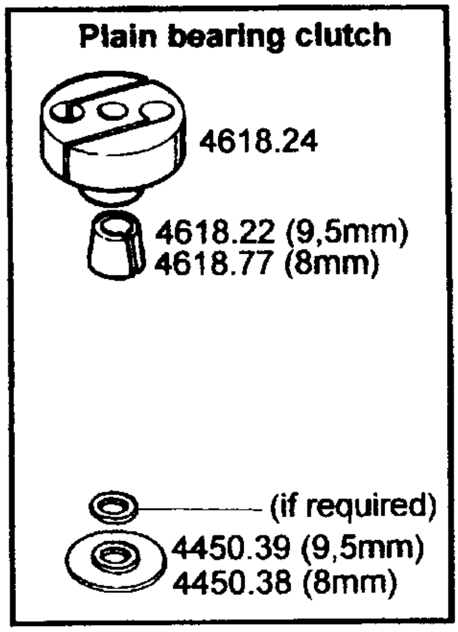


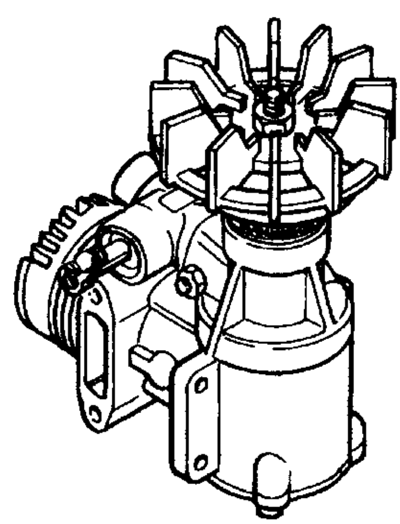
1.5 Installing the motor *(bag U6-2)*

1.5.1 Preparing the motor

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 4618.23A or 1239, 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.



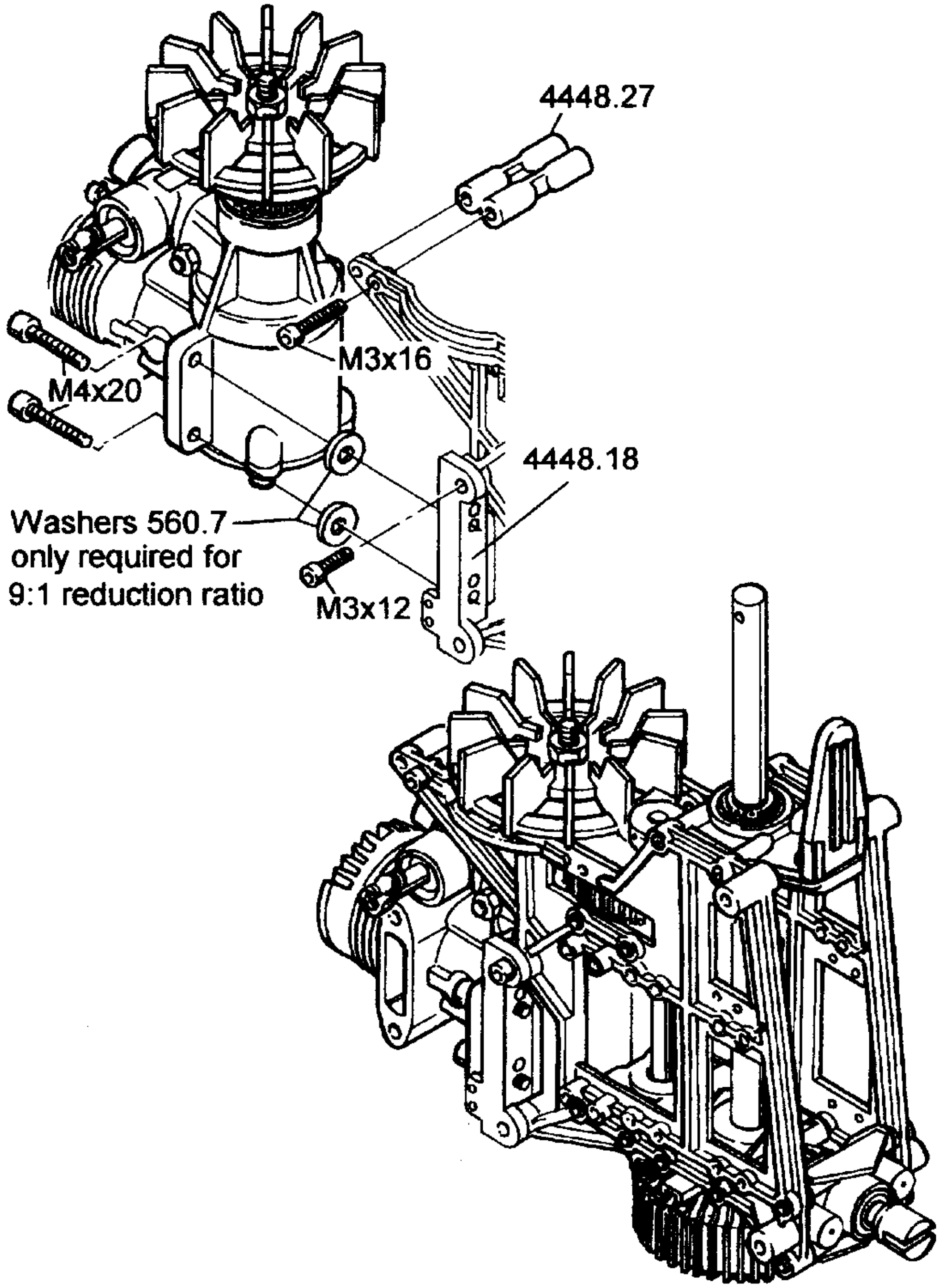




Notes:
Power transference between crankshaft and clutch is achieved exclusively by the clamping pressure of the taper collet on the ground crankshaft nose, and on the tapered socket in the clutch. To ensure that sufficient pressure is applied, it has proved good practice to start by installing the clutch 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).

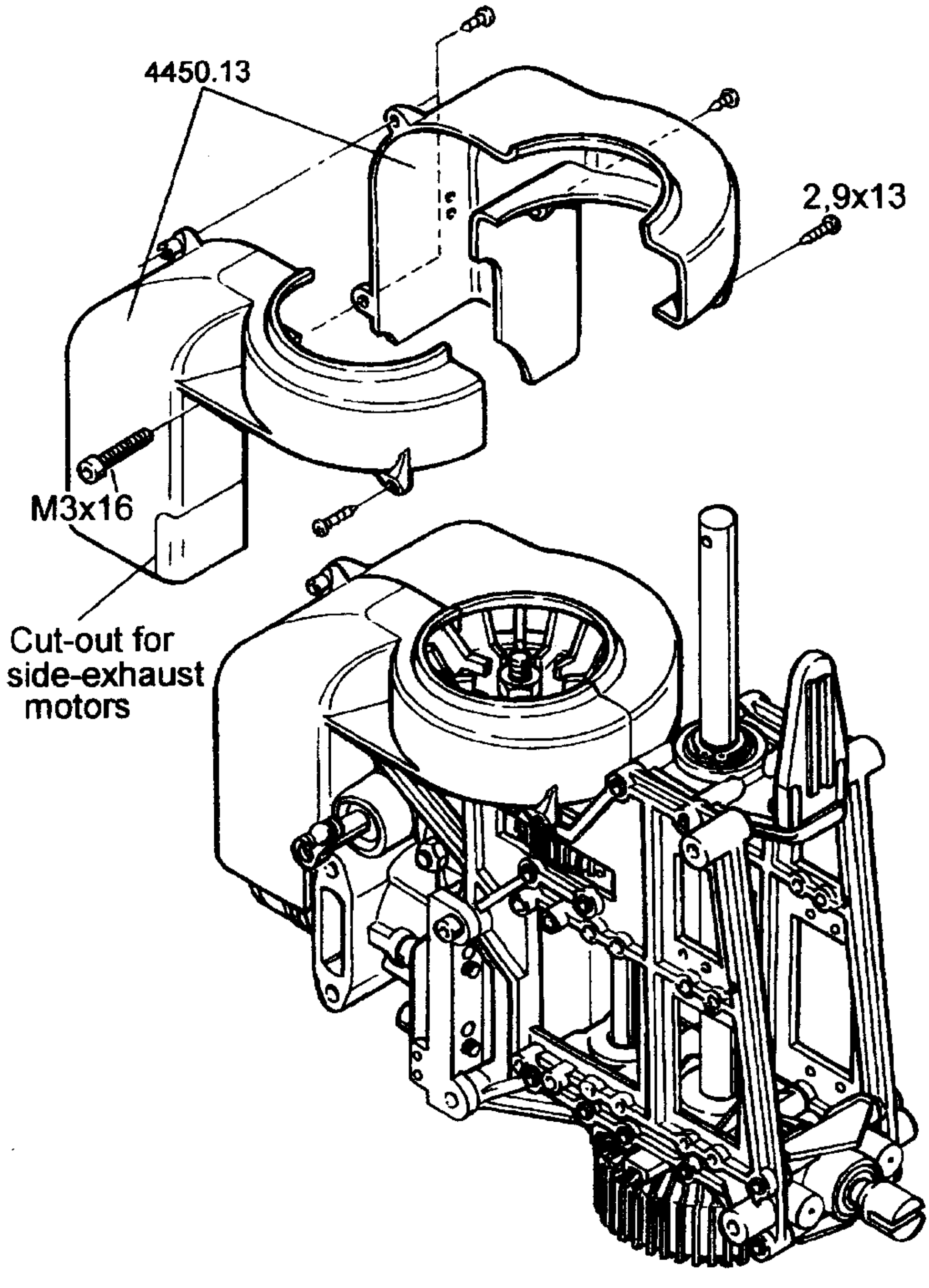
1.5.2 Installing the prepared motor

Fix the motor mounts 4448.18 to the motor using four M4 x 20 screws. If you are using the 9:1 reduction ratio, fit the washers 560.7 (9/4.3 x 0.8) between the motor mounting lugs and the motor mounts. Fit this assembly into the mechanics from the front (you will need to swivel it round slightly) and secure it using the stated sizes of socket-head cap screws. Fit the cross-piece 4448.27 using M3 x 16 screws as shown.



Check that the universal motor mounts 4448.18 are installed correctly:
The **lower threaded holes** in the motor mounts must be **19 mm** from the **bottom edge** of the motor mounts; if that is not the case, the right and left motor mounts must again be swapped over.

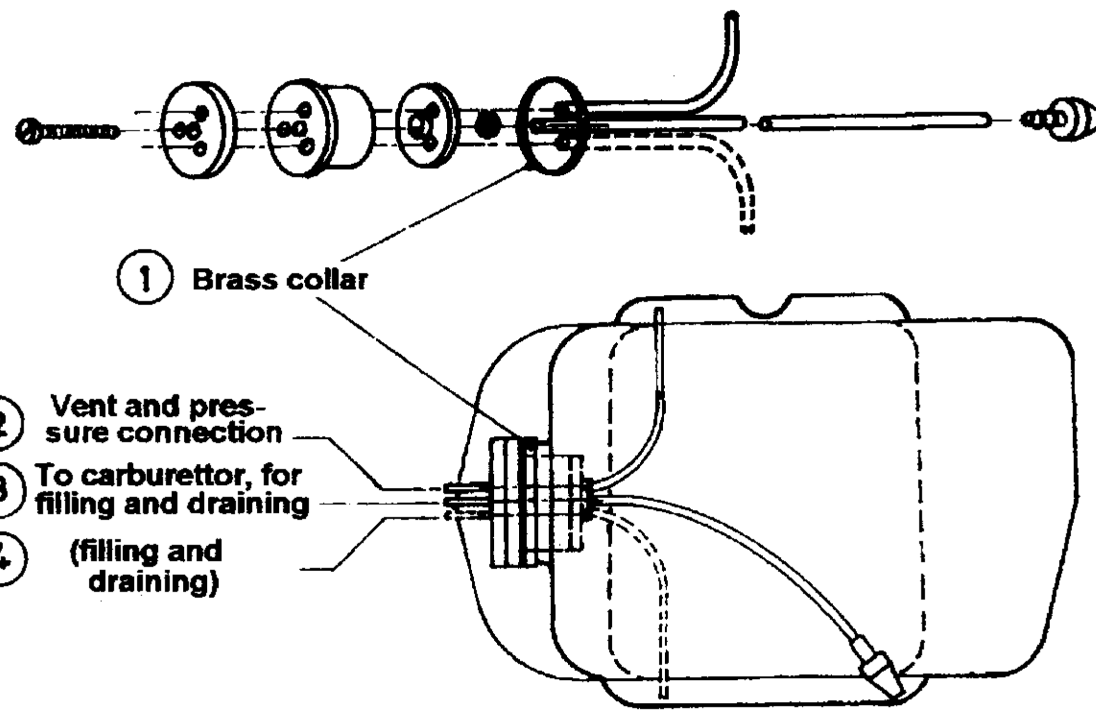
1.5.3 Installing the cooling fan housing *(bag U2-3)*



You may need to enlarge the carburettor opening in the fan housing, depending on the carburettor you are using.
If you have installed a **side-exhaust** two-stroke motor, you will also need to cut an opening in the left-hand side to provide clearance for the exhaust manifold (see illustration); use a fretsaw for this.
Slide the fan housing over the motor and fix it to the mechanics with two 2.9 x 13 self-tapping screws at the rear, and two M3 x 16 socket-head cap screws at the front.

1.5.4 Fueltank *(bag U2-6)*

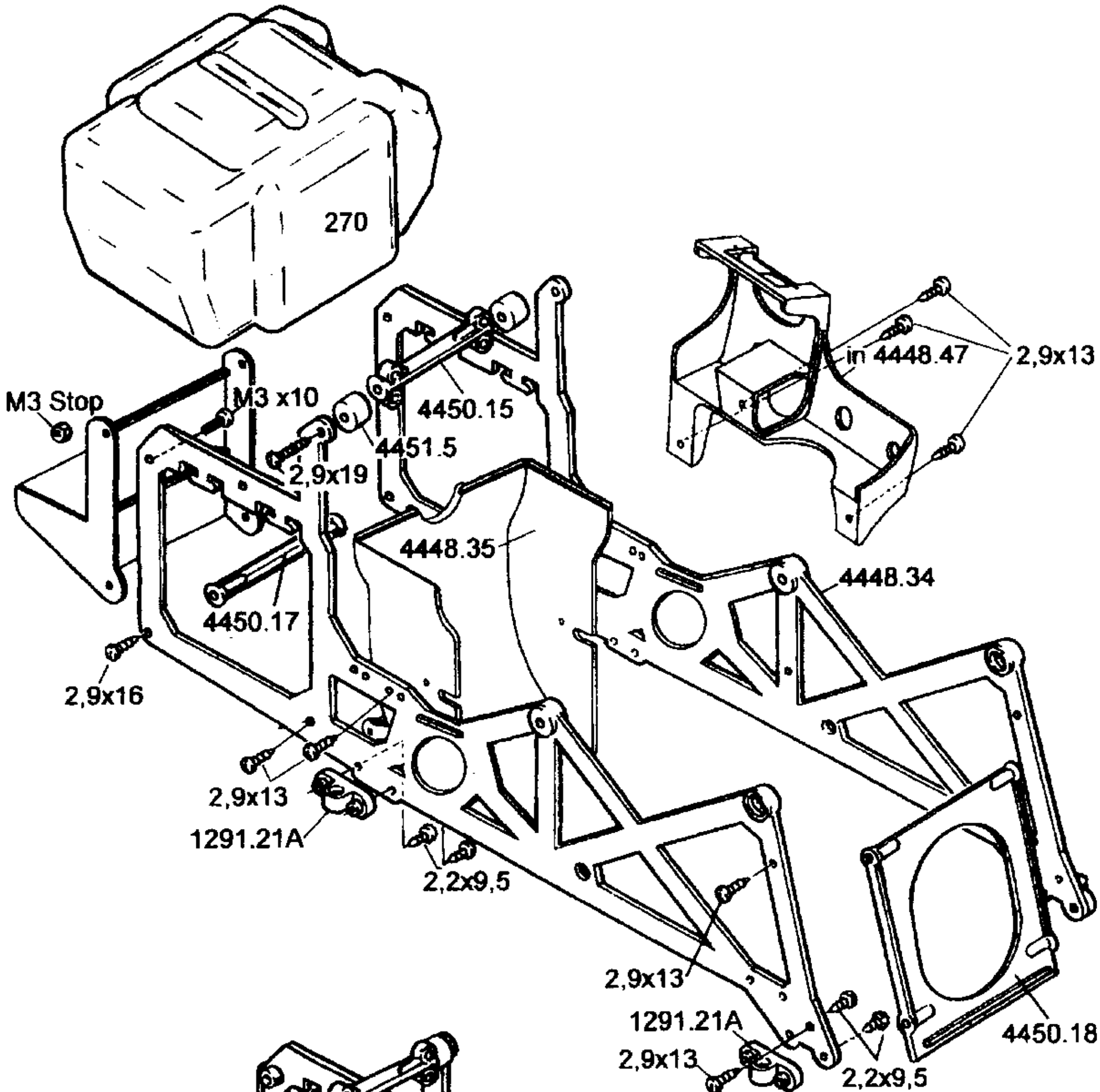
The shape of the fueltank has been designed specifically to suit the helicopter mechanics; the bung should be on the right-hand side. Bend the metal tube (or tubes) to the shape shown in the drawing. The tube ends must be located right at the top and right at the bottom of the tank. Check that the clunk weight is completely free to move, and that it always falls to the bottom when you swivel the tank by hand. Push the brass collar over the neck of the tank; it ensures that the neck cannot burst when the screw is tightened and the rubber bung is compressed.
The fueltank is assembled as shown in the exploded drawing. The rubber bung features a hole for the retaining screw, plus two through-holes for the brass tubes, and a third „blind" hole (for other optional purposes). The third hole can easily be continued through the bung if you wish. Assemble the fueltank, then tighten the central screw firmly to expand the rubber and seal all the joints.
The tube running to the top of the tank (the vent) should be used as the pressure line, and for this purpose it is connected to the pressure take-off nipple on the silencer. If you prefer to use only one tube (the top one) in addition to the clunk feed line, then you must disconnect the fuel line between the clunk weight and the carburettor for filling and draining the tank. You can avoid this awkward procedure by installing a two-way filler valve, Order No. 1657, in the appropriate hole in the switch console, and loop it into the fuel line from the fueltank to the carburettor; if you don't fit this valve, you will have to pull the feed line off the carburettor every time you refill the tank.
Make up the fuel line to the motor using fuel tubing and a fuel filter; note that the connection to the carburettor should be as short as possible.

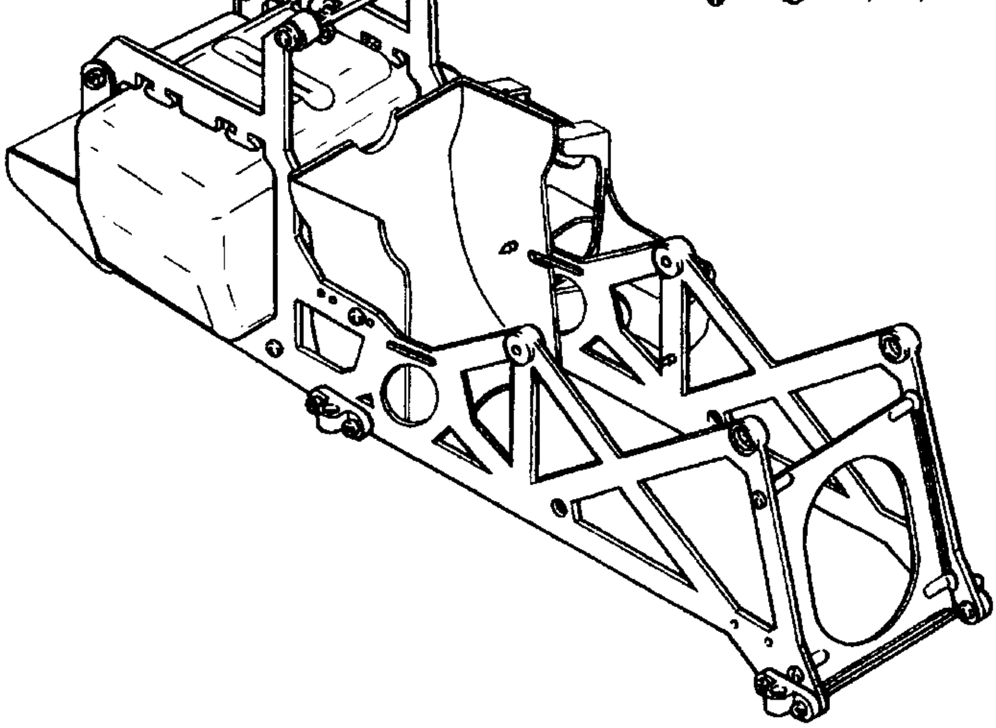


1.6 Assembling the chassis sub-structure *(bag U2-4)*

Assemble the chassis sub-structure from the components shown in the illustration, using the stated sizes of screws.

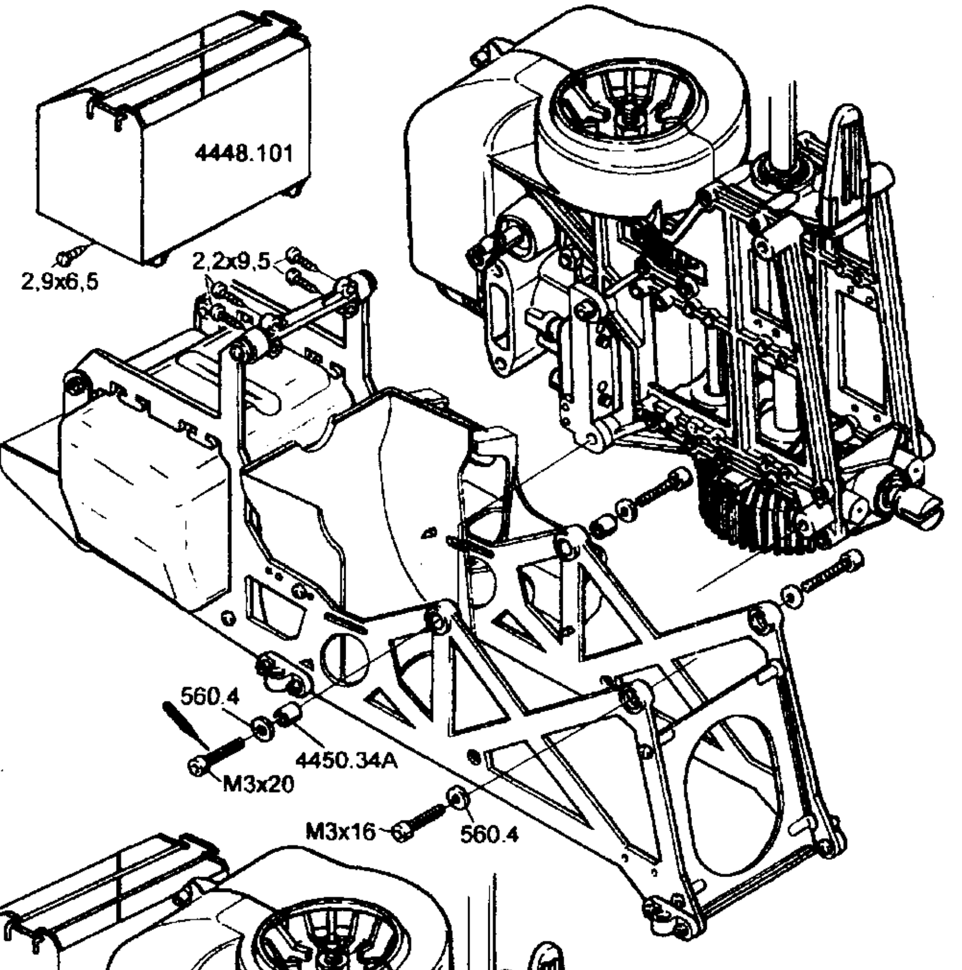
Note:
Remove all rough edges from the side frames 4448.34 where they contact the fueltank.

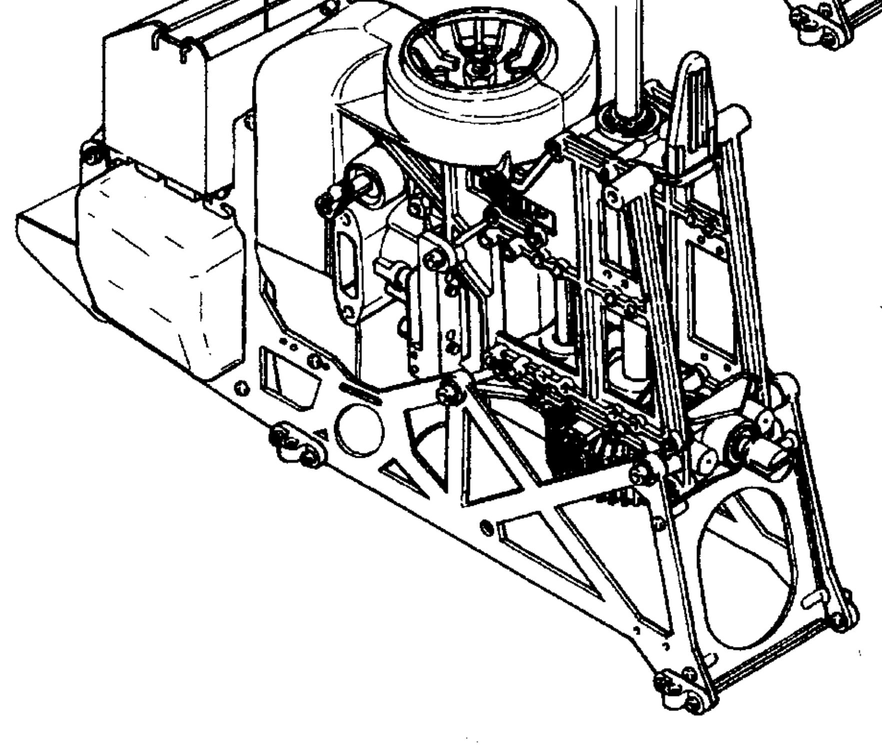

270
M3 Stop
M3 x10
2,9x19
4450.15
4451.5
in 4448.47
2,9x13
4448.35
4448.34
4450.17
2,9x16
2,9x13
1291.21A
2,2x9,5
2,9x13
1291.21A
2,9x13
2,2x9,5
4450.18



1.7 Attaching the mechanics to the sub-structure *(bag U2-5)*

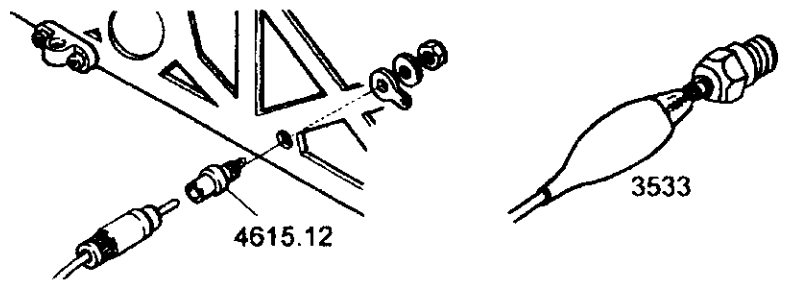
Place the main gearbox (from Stage 1.5) between the sub-structure side frames, engage the round shoulders in the sockets, and fit the M3 x 16 socket-head cap screws and washers to hold the parts together. At the front the mechanical aggregate is secured using M3 x 20 socket-head cap screws as shown in the illustration. Drill 1.5 mm Ø pilot-holes in the fan housing, and fix the front structure adaptor 4450.15 to the fan using 2.2 x 9.5 self-tapping screws. Attach the RC box 4448.101 as shown.





When you need access to the glowplug, remove the two lateral retaining screws and fold the RC box to the side.
At this stage the meshing clearance of the first gearbox stage should be adjusted as follows: loosen the M3 x 12 screws on the sides of the motor mounts, run a strip of thin cartridge paper between the gears, and tighten the screws again firmly in this position after applying plenty of thread-lock fluid to the threads. Remove the paper strip, and the gearbox should rotate freely.

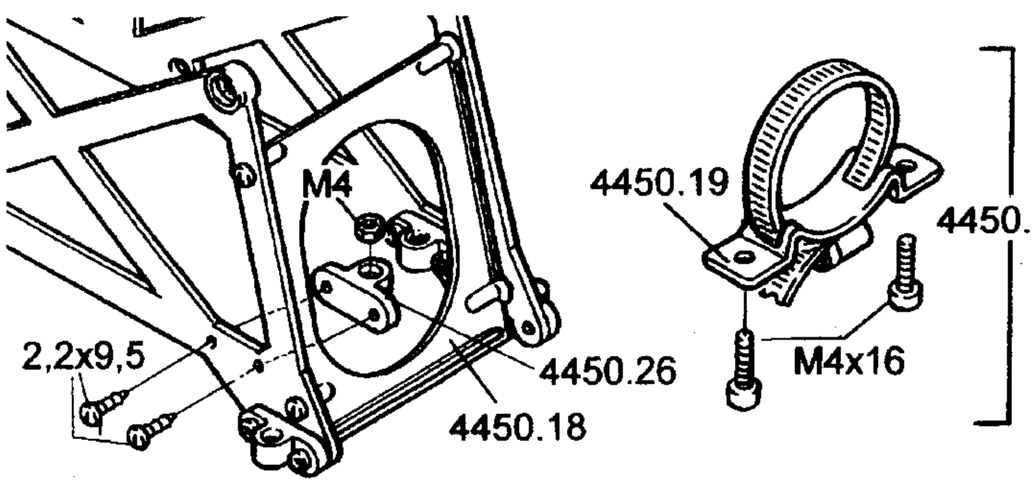
1.8 Remote glowplug connection *(bag UM-6A)*



Work out the best position for the remote glowplug socket to suit your model, and fit the socket in one of the two holes in the switch console, or in the hole in the left-hand sub-structure side frame. Fit the solder tag, washer and nut on the socket in that order, and tighten the nut to secure the socket.
The socket can now be connected to the motor using the twin-core cable supplied. The crocodile clip is designed to provide easy access to the glowplug in order to fit a new one, and the clip should be soldered to the wire running from the centre contact of the socket. Attach the crocodile clip to the glowplug, and fix the other wire to one of the motor mount screws using an additional washer. Deploy the cable neatly, then solder one wire to the positive terminal of the socket, the other to the negative terminal.

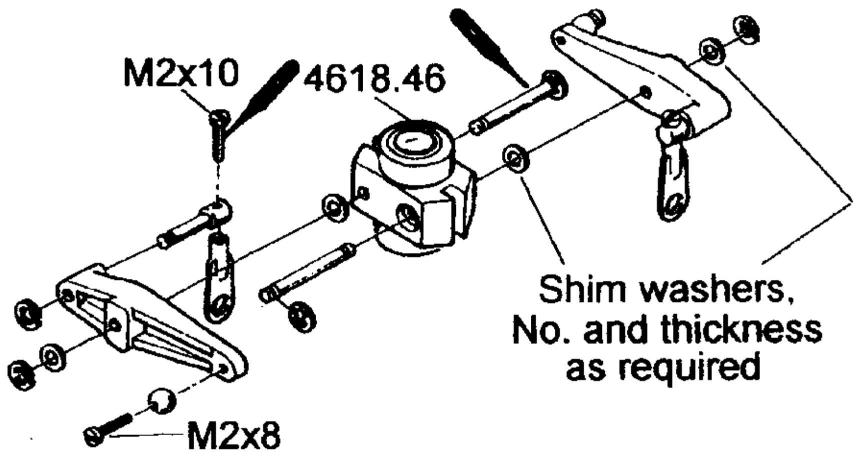
1.9 Silencer

Select the appropriate exhaust manifold to suit your motor, and install it in such a way that the exhaust runs below the motor, and is directed towards the rear inside the sub-structure. Thread the silencer through the rear bulkhead 4450.18 from the rear, and connect it to the manifold using Teflon hose and hose clips; leave about 5 mm clearance between the manifold and the silencer inlet stub.
The method of supporting the silencer tailpipe varies according to the silencer used. An exhaust holder (e.g. UNI-STAR 60) can be used at the rear end to support the tailpipe, or it can be supported at the fuselage exhaust outlet or - preferably - by means of a console (available separately, Order No. 4450.149). In this case the silencer is supported at the centre, and secured by tightening the clip provided. Take care not to overtighten the clamping screw.
In this case the two brackets 4450.26 should be screwed to the sub-structure at a suitable position, using the existing holes as reference points; note that the actual screw positions may have to be located differently to suit your silencer.

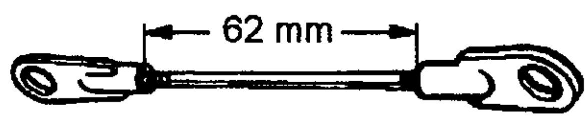


1.10 Collective pitch compensator and swashplate *(bag UM-8, UM-9)*

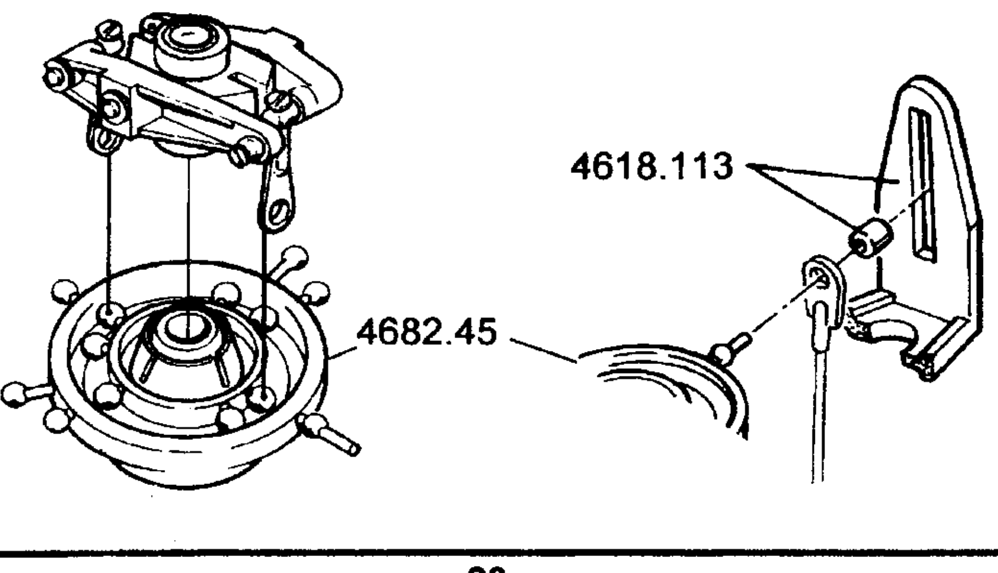
The collective pitch compensator 4618.47A is assembled as shown in the drawing. First fit a circlip on each of the brass rods, and glue them in the holes in the collective pitch compensator hub 4618.46 using bearing retainer fluid, ensuring that the circlips engage fully in the recesses. De-burr the 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.



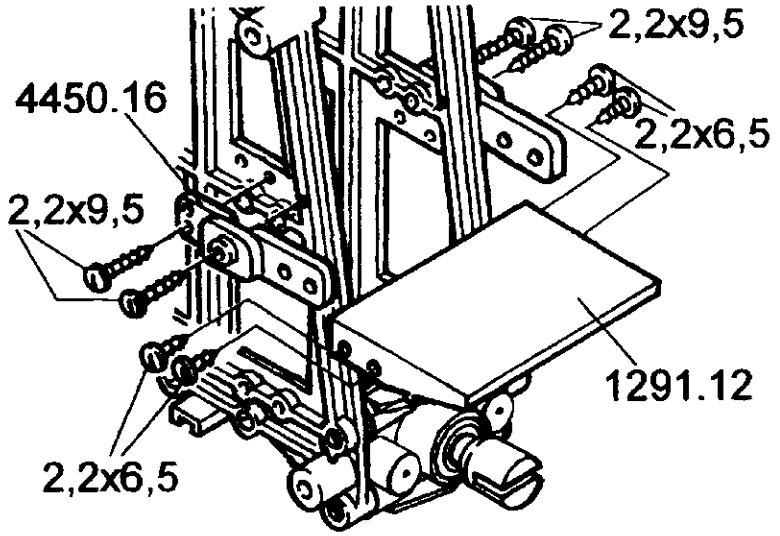
Make up three pushrods as shown in the drawing, using the threaded rods 4450.51 (2 mm Ø, 75 mm long) and six ball-links 4618.55. The stated dimension refers to the actual clearance between the ball-links, as shown.



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.



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



Fix the gyro platform holder 4450.16 to the side frames using 2.2 x 9.5 self-tapping screws. Fit the gyro platform 1291.12 on top, and secure it with four 2.2 x 6.5 self-tapping screws.

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

2.1 Mounting the servos

Fit brass linkage balls on the *inside face* of the output arms of the pitch-axis servo (1) and the roll servos (2) + (3) using M2 x 10 cheesehead screws, and secure each one with an M2 nut fitted on the outside. Apply thread-lock fluid between the screws and the balls, and also in the nuts. The distance from the servo output shaft axis to the ball centre should be around 18 mm. Install the pitch-axis servo in the rectangular opening in the right-hand side frame, working from the inside; the output shaft must be at the top. Secure the servo with four screws, rubber grommets and tubular rivets (these items are supplied with the servos): the tubular rivets are pressed *into the underside* of the rubber grommets, and the screws fitted *from the top.*

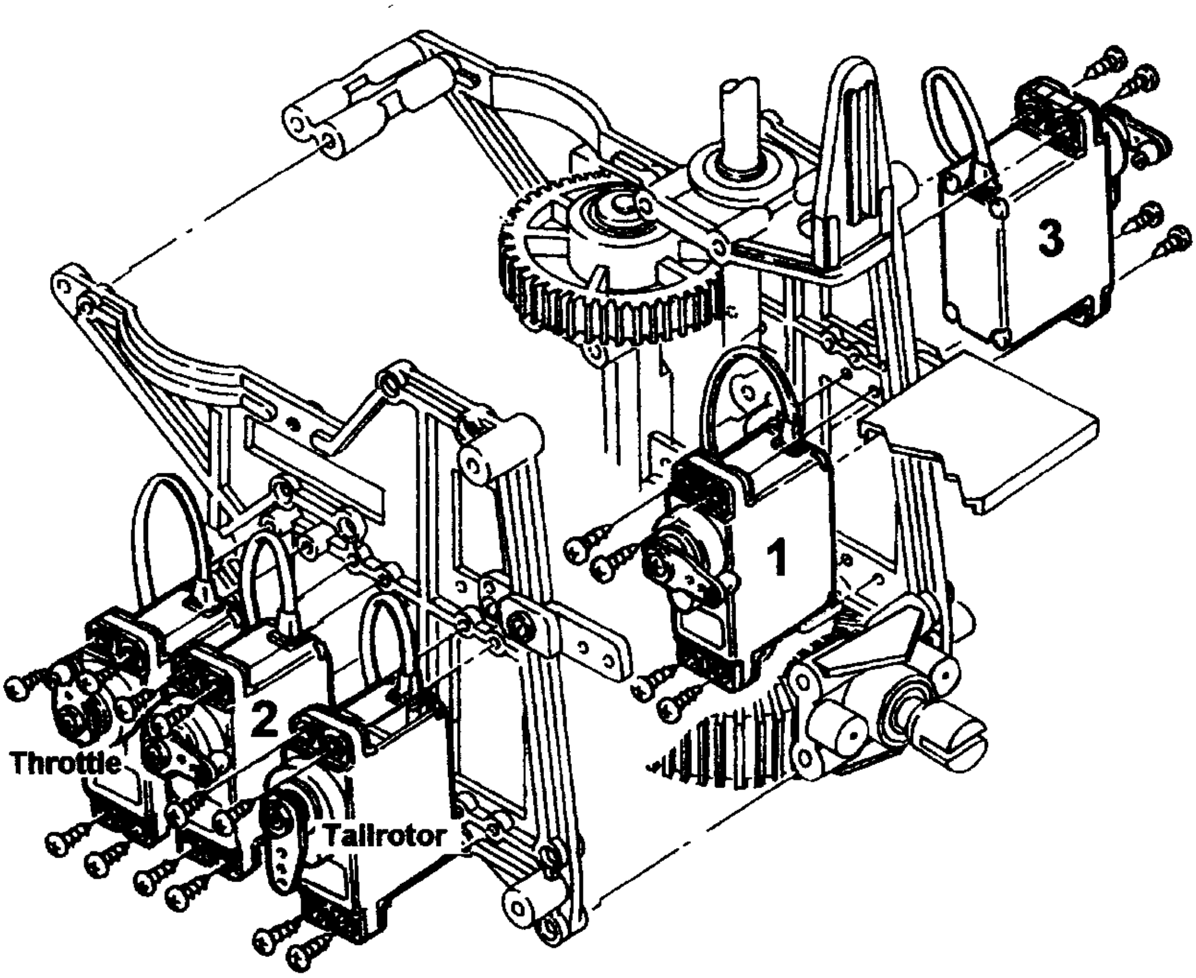
The holes in the mechanics for the servo mounting screws are deliberately offset slightly towards the outside, so that the rubber grommets are under slight tension when the screws are fitted. This helps to produce precise control response.

Both the roll-axis servos are fitted in the right and left side frames working from the outside, again with the output shafts at the top (see drawing). Secure each servo with four screws as before. Connect the servos to the receiver in the sequence described in the RC system instructions, switch on the radio control system and activate the swashplate mixer at the transmitter (setting: symmetrical three-point linkage, two roll-axis servos, one pitch-axis servo at the rear). Set the collective pitch, pitch-axis and roll-axis controls to neutral (centre) and fit the output arms on the servos at right-angles to the rotor shaft. Secure them with the servo output screws.

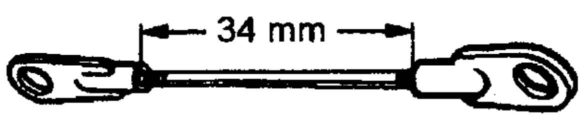
The tail rotor servo is installed in the left-hand side frame from the outside, with its output shaft at the top; secure it with screws in the usual way. The output arm of the tail rotor servo must face down, and should be parallel to the main rotor shaft when the collective pitch control is at centre.

Fix a brass linkage ball o*n the outside face* of the throttle servo output arm using an M2 x 10 cheesehead screw, and secure it from the rear with an M2 nut, applying thread-lock fluid between the screw and the ball, and also in the nut. The distance from the servo output shaft axis to the ball centre should be around 11 mm. The throttle servo is installed in the left-hand side frame with the output shaft at the top and the servo output arm facing up.

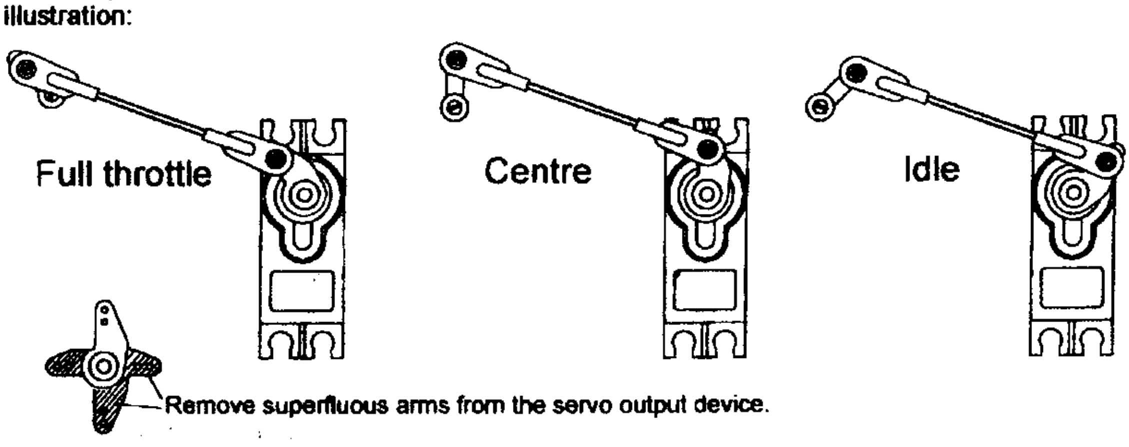
Deploy the servo leads along the chassis to the RC box, taking the greatest care to avoid potential sources of damage. Do not allow any cables to touch shafts or gears, as they could easily chafe through, and cause a short-circuit and crash.



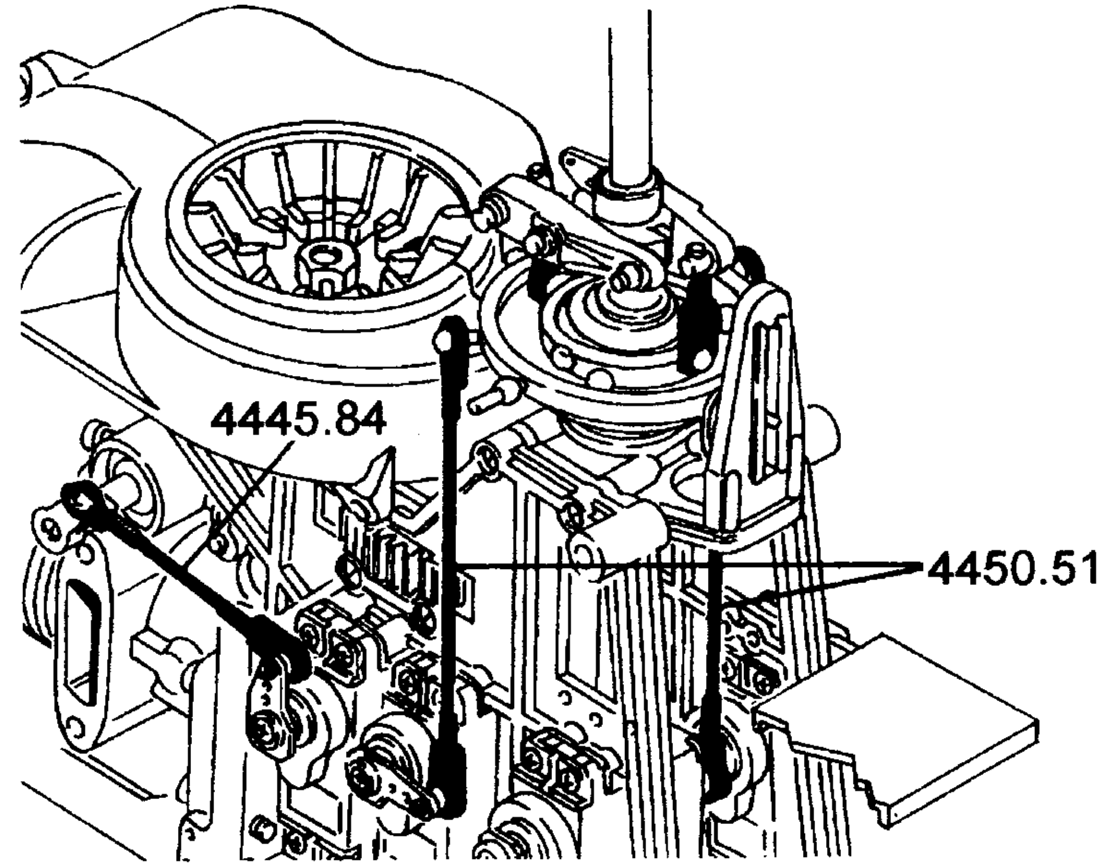
Make up the throttle pushrod from one threaded rod 4445.84 (2 mm Ø, 45 mm long) and two ball-links 4618.55 as shown in the illustration; the stated dimension refers to the free space between the ball-links.



Use this pushrod to connect the carburettor arm to the servo output arm as shown in the illustration:



Connect the swashplate servos to the swashplate to produce a 120° linkage, using the previously prepared pushrods.



A four-point swashplate linkage is also possible, but you will need to use your own discretion for the detail solution. In this case an additional servo is installed in the vacant servo aperture in the mechanics, and should be connected to the front linkage point on the swashplate by means of a 2.5 mm Ø pushrod which will need to be angled for clearance. In this arrangement the pushrods from servos 2 and 3 are connected to the lateral (90°) linkage points on the swashplate. You will need to activate the swashplate mixer for a four-point linkage at the transmitter.
If you wish to install a four-point linkage, please pay particular attention to accurate adjustment of the linkage pushrods, otherwise the servos may place strain on each other. This is the procedure: with the radio control system switched on, set the collective pitch stick to centre (the servo output arms should be at 90° to the pushrods), then disconnect one pushrod. Now adjust the remaining three pushrods until the swashplate is exactly horizontal. When you are satisfied, adjust the length of the fourth pushrod so that it can be pressed onto the linkage ball on the servo without causing any movement in the other pushrods.

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. Run the cables forward along the side of the mechanics to the receiver, together with the servo leads.

Pack the receiver battery in soft foam, such as the foam sleeve, Order No. 1637, then mount it on the battery console and secure it with two cable ties.

The receiver, gyro electronics and speed governor (if present) can be installed in the RC box. Pack these items in soft foam and secure them by fitting the wire retainer bar.

Bundle together all the servo, gyro and battery leads, and wrap them in spiral tubing or fit cable ties round them. Run the loom forward to the receiver and fix it to the side of the mechanics.

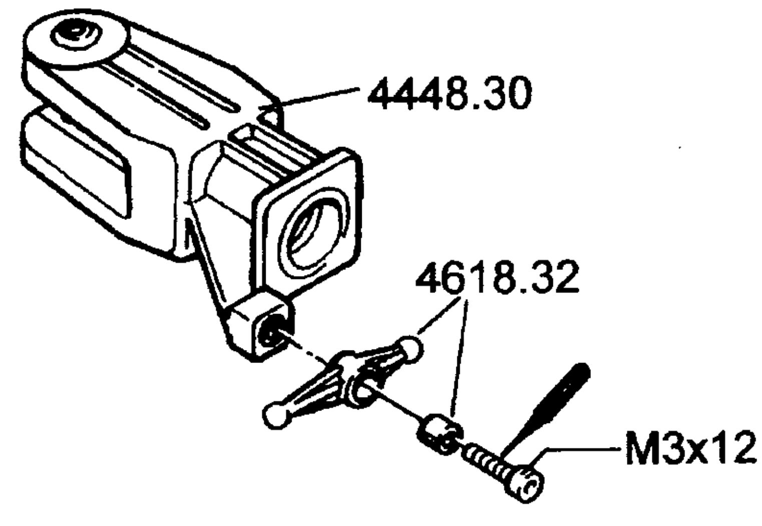
Attach the receiving system switch to the switch console mounted on the right-hand side of the sub-structure, and connect it to the battery and receiver.

3. Assembling the main rotor head *(bag U6-10)*

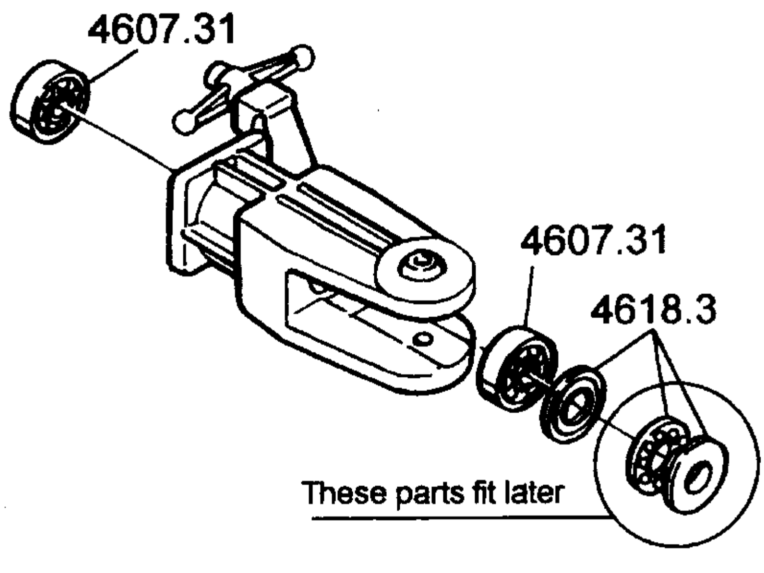
The main rotor head is assembled as shown in the illustrations. Remember to grease all ballraces.

3.1 Preparing the rotor blade holders *(bag U6-10A, U2-10B)*

The first step is to glue the brass sleeves from 4618.32 to the M3 x 12 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, applying thread-lock fluid at the M3 x 12 screws.



Press the radial bearings 4607.31 and the bearing disc of the thrust bearing 4618.3 into the blade holders as far as they will go, as shown in the illustration.

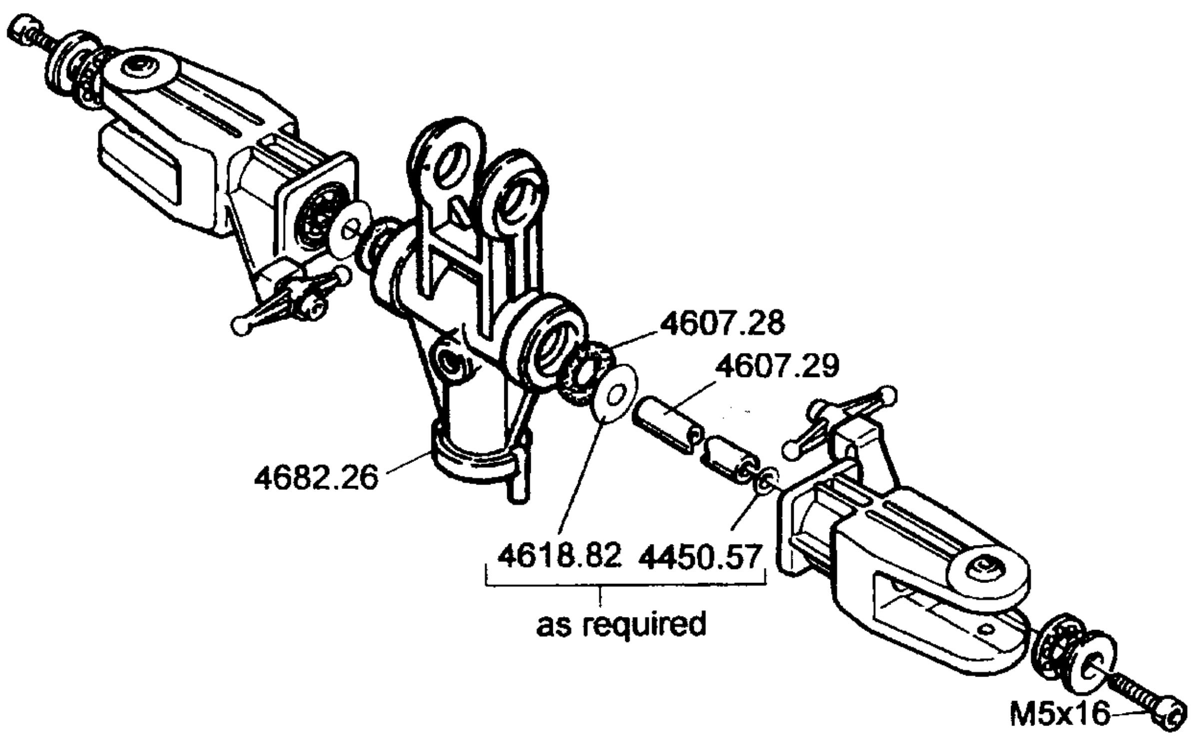


Now check that the bearings 4607.31 in the prepared blade holders are an easy sliding fit on the blade pivot shaft 4607.29. If necessary relieve the blade pivot shaft by rubbing down with fine abrasive paper (600-grit or finer) until the bearings are a smooth sliding fit.

3.2 Installing the blade holders

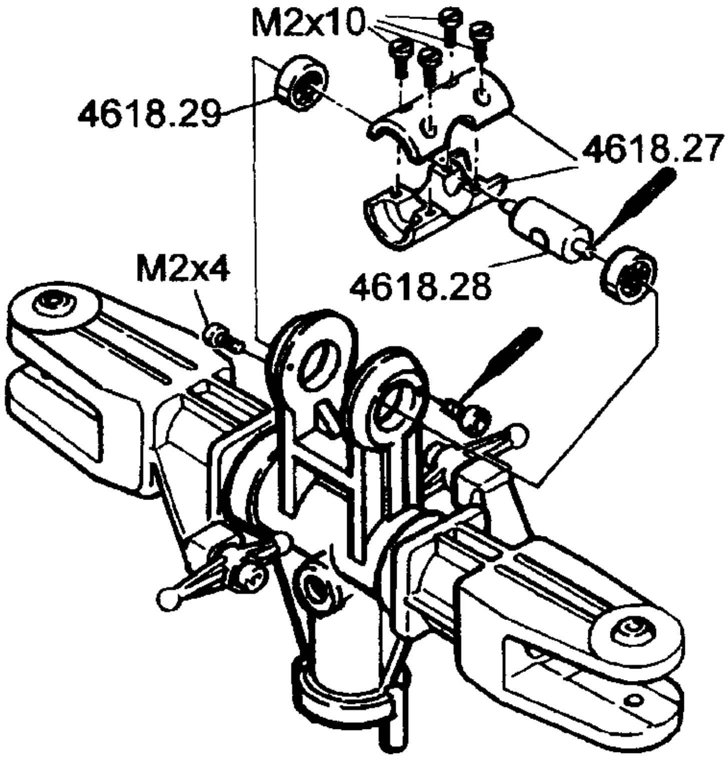
Press the two O-rings 4607.28 into both sides of the rotor head centre piece 4682.26, grease the blade pivot shaft and slide it through. Centre the shaft, so that it projects by an equal amount on both sides, then check that the O-rings are still in place. Fit 0.3 mm shim washers (from 4450.56) on the shaft on both sides of the centre piece, followed by the blade holders, noting that the blade holders must be orientated correctly: the blade pitch arm carrying the mixer lever must be in front of the blade (see illustration). Thoroughly grease the ball cages and thrust washers of the thrust bearings 4618.3, fit them on the shaft and tighten the two M5 x 16 socket-head cap screws.

Check that the blade holders rotate freely, and if necessary tap on the blade holders and the centre piece with a screwdriver handle to encourage the bearings to seat themselves correctly, so that they are not under strain. If the blade holders do not move freely because they are pressing against the centre piece, fit a spacer washer 4450.57 between the thrust washer of one of the two axial bearings and the blade pivot shaft.
Once you are satisfied that the blade holders rotate freely, apply thread-lock fluid to the M5 x 16 socket-head cap screws, and tighten them fully and permanently. If you had to fit a spacer washer 4450.57, take care not to over-tighten the socket-head screw, to avoid deforming the brass washer.

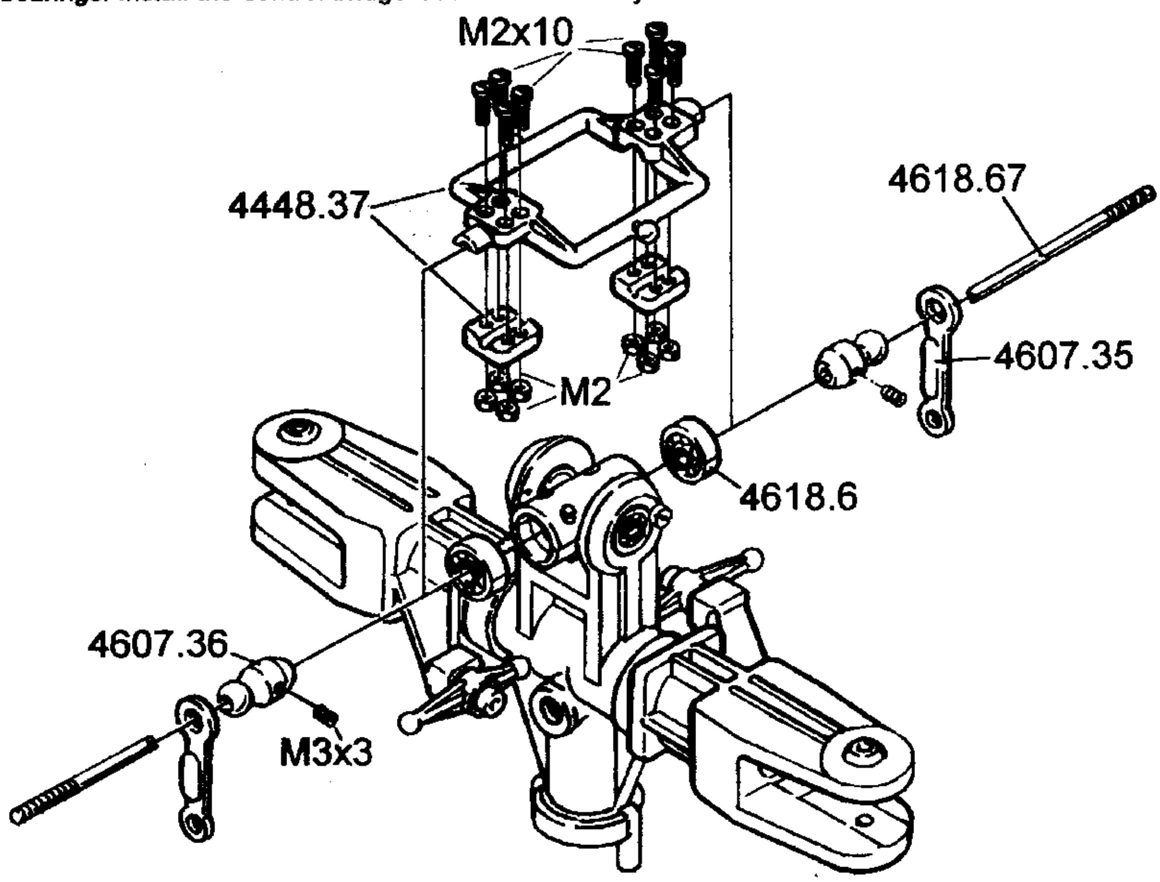


3.3 Assembling the Hiller rotor *(Beutel UM-10C, U2-10D)*

The rocker 4618.27 is assembled and installed as shown in the illustration. The hole in the pivot rod 4618.28 must line up with the axial bore in the rocker, so that the flybar can be fitted through it later without jamming or binding. Initially the two rocker shells are held together temporarily using four M2 x 10 screws. Secure each of the two ballraces on the outside by fitting an M2 x 4 screw in the centre piece. Check that the rocker rotates freely.
Roughen the flybar with abrasive paper at the points where the control bridge 4448.37 will be clamped. The control bridge is screwed in place, applying thread-lock fluid between the flybar and the control frame; this prevents any danger of the flybar twisting in the control bridge during violent aerobatic manoeuvres.

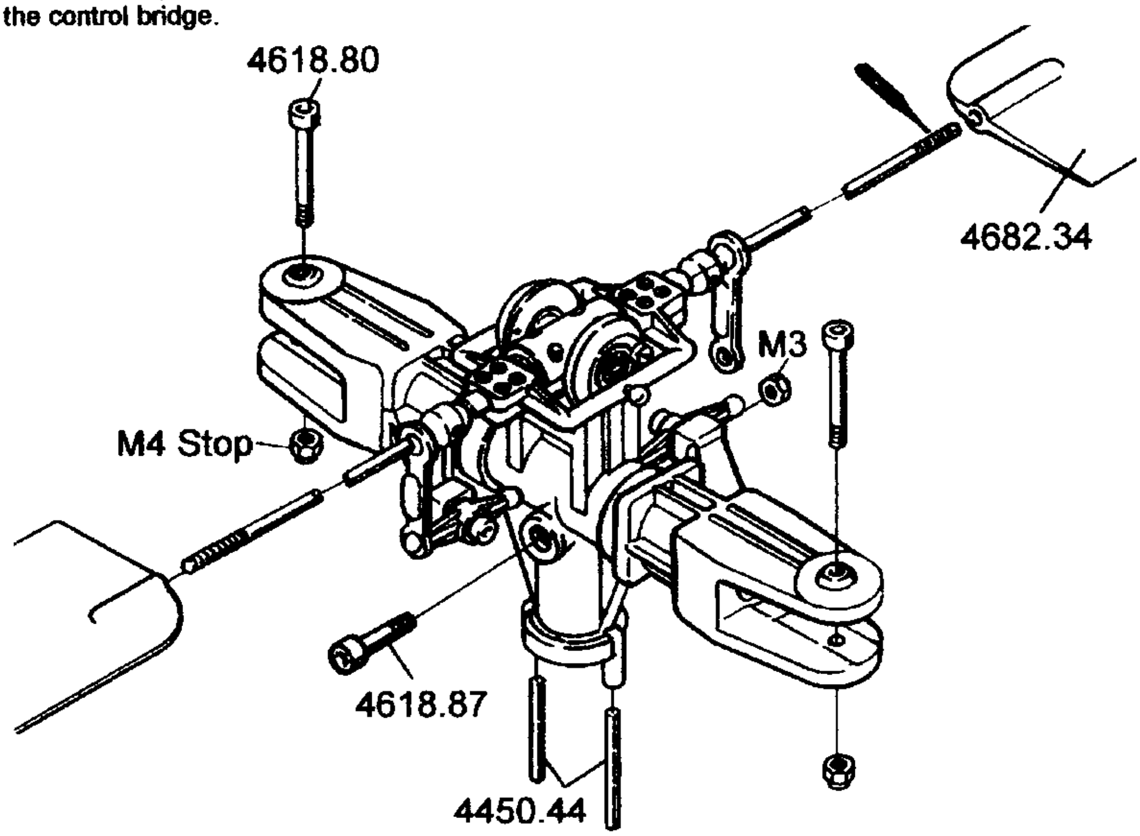


Press the ballraces 4618.6 into both sides of the rocker. Fit the flybar 4618.67 through the rocker and set it exactly central, i.e. it must project by the same amount on both sides of the bearings. Install the control bridge 4448.37 as already described.



Fit the ball collets 4607.36 on both ends of the flybar, and slide them along until they rest against the control bridge. Apply thread-lock fluid to the threaded holes in the ball collets, then fit and tighten the M3 x 3 grubscrews. Press the double ball-links 4607.35 onto the collets.

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.

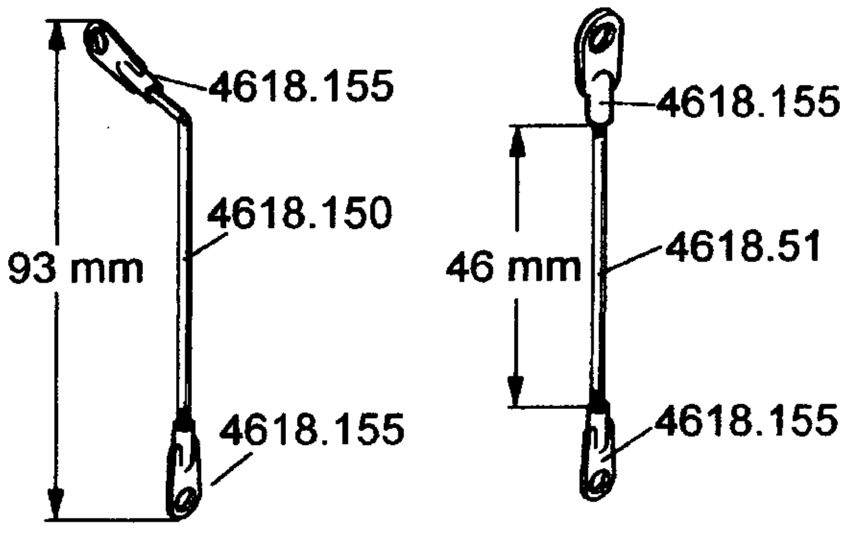


Apply thread-lock fluid to the two guide pins 4450.44 for the collective pitch compensator, and press them into the rotor head centre piece.

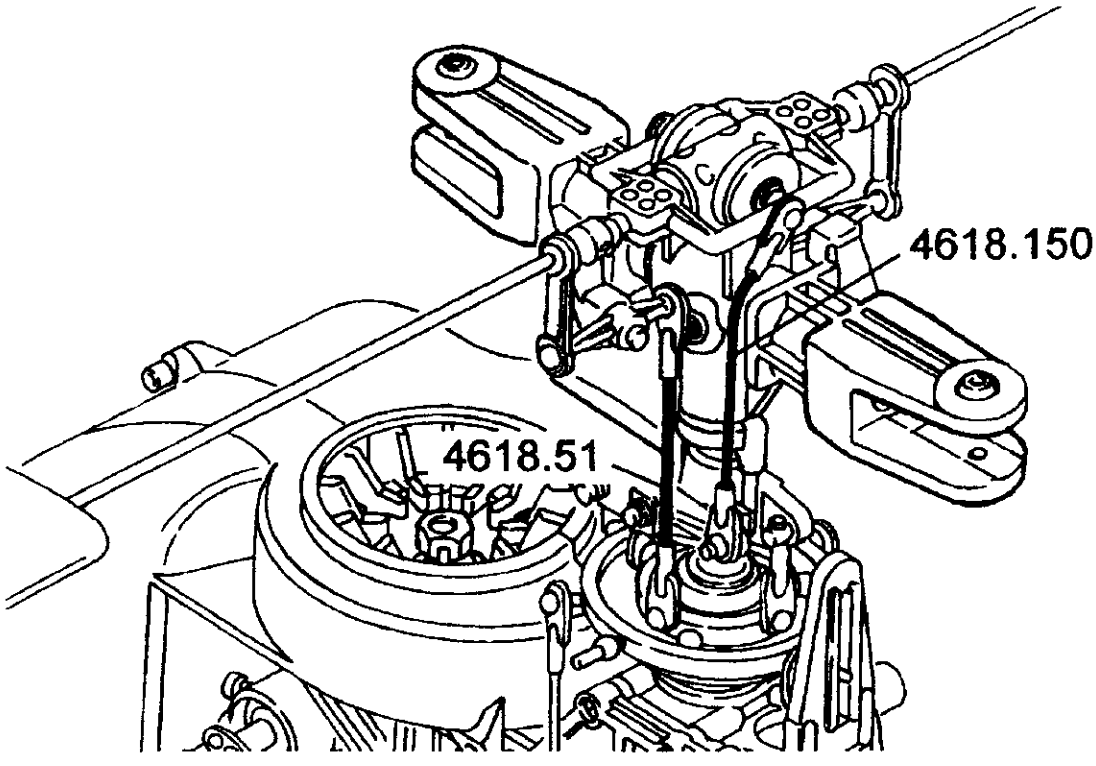
4. Installing the main rotor head *(bag UM-9A)*

Place the main rotor head on the main rotor shaft, and line up the hole in the rotor head with the upper cross-hole in the main rotor shaft. Insert the special screw 4618.87 and tighten it to secure the rotor head.

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



The pushrods 4618.150 and 4618.51 are made up and installed as shown in the drawing.



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

Slide the swashplate up as far as it will go (you may have to disconnect the ball-links on the outer ring to make this possible). The swashplate should then rest exactly against the collective pitch compensator when the compensator itself rests against the underside of the main rotor head. If this is not the case, you must adjust the angled pushrods 4618.150 as follows:

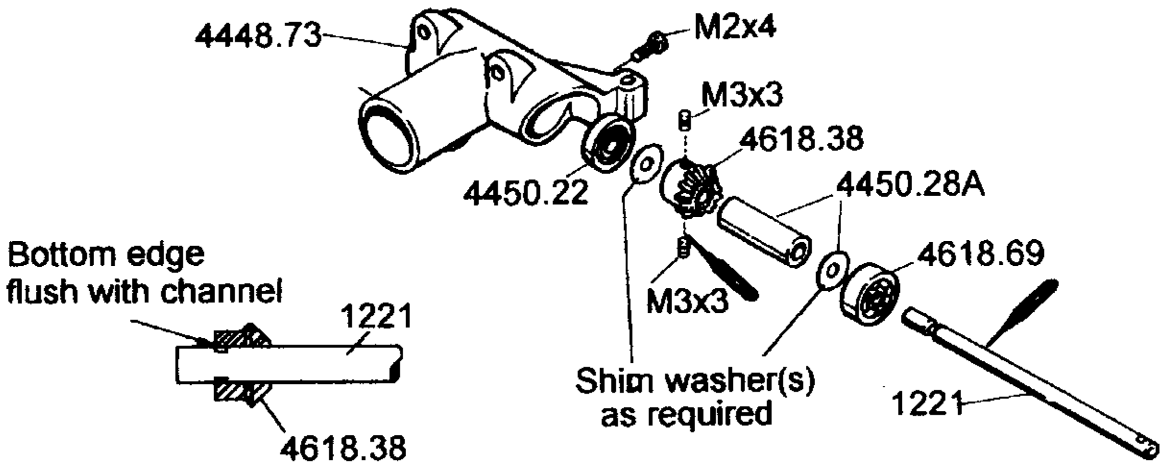
- The swashplate contacts the collective pitch compensator, but there is a gap between the collective pitch compensator and the rotor head there: ➔ shorten both pushrods.
- The collective pitch compensator contacts the rotor head, but there is a gap between the swashplate and the collective pitch compensator: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

Note that it is essential to adjust both pushrods by the same amount, i.e. they must remain the same length.

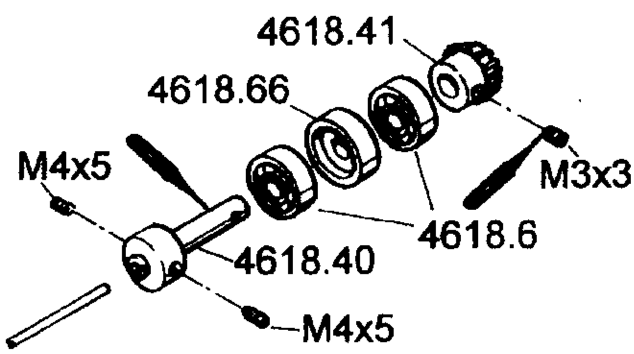
The final step is to carry out the fine adjustment of the auxiliary rotor, to ensure that the Hiller paddles are exactly parallel to the swashplate when the swashplate is set horizontal. If you need to make adjustments here, rotate the pushrods 4618.150 in opposite directions by the same amount; don't adjust only one pushrod!

5. Assembling the tail rotor gearbox *(bag U6-11, UM-11A)*

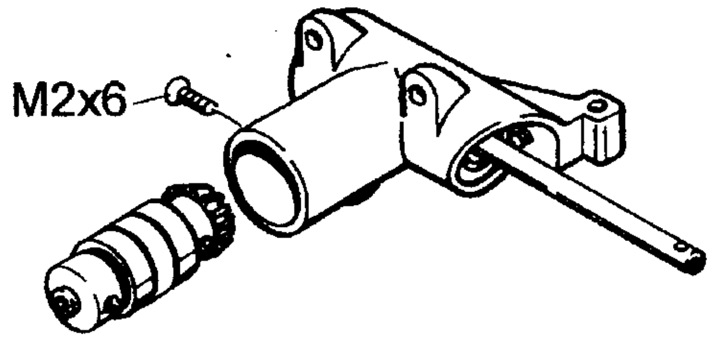
Fit the bevel gear 4618.38 on the tail rotor shaft 1221 as shown in the drawing. Apply a drop of thread-lock fluid to the threaded holes in the bevel gear, then fit the M3 x 3 grubscrews. One of the two grubscrews must engage squarely on the machined flat in the tail rotor shaft. Take care not to tighten 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 4618.73 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 4618.6, the spacer 4618.66 and the bevel gear 4618.41 on the tail rotor input shaft 4618.40 as shown in the illustration. Fit the M3 x 3 grubscrews in the bevel gear so that they engage in the depressions in the shaft. Don't tighten the grubscrews fully at this stage. Now check that there is no axial play in the bearings on the shaft; if necessary fit a 4 mm I.D. shim washer on the **outside**, between the coupling and the outer bearing.
Loosen the grubscrews in the bevel gear, withdraw these parts from the shaft again and apply bearing retainer fluid, Order No. 951, before re-fitting them. Apply thread-lock fluid to the holes in the bevel gear and tighten the grubscrews fully, as described above. 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.



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 6 countersunk screw.
Fit a steel rod (screwdriver blade or similar) through the threaded holes in the coupling 4618.40. 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.

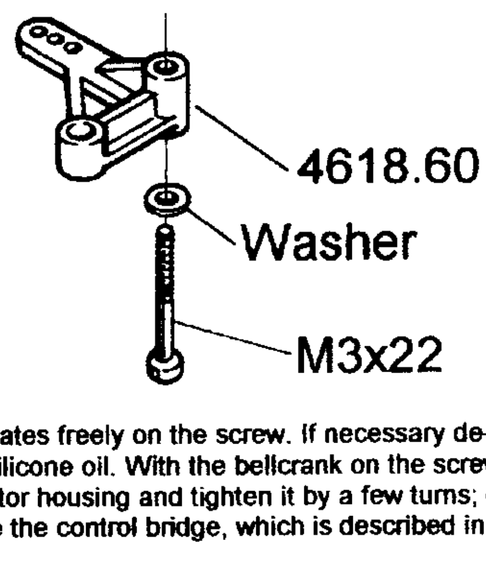


If the play in the gears is too slight, i.e. the gears are stiff to move, you will need to remove the drive assembly again and refit it with the hole in the spacer 4618.66 **offset** relative to the hole in the tail rotor housing. If you work carefully, making small adjustments, it is possible to set up the bevel gears so that they work freely but **without** backlash. When you are satisfied with the set-up, use a 1.5 mm Ø drill applied through the hole in the tail rotor housing to cut a new hole in the spacer 4618.66. The M2 x 6 countersunk screw will now engage in the new hole. 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 4618.38 is located too far outward due to manufacturing tolerances, and is not engaging correctly with the bevel gear 4618.41. 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, re-fit them on the tail rotor shaft, and assemble the parts permanently.

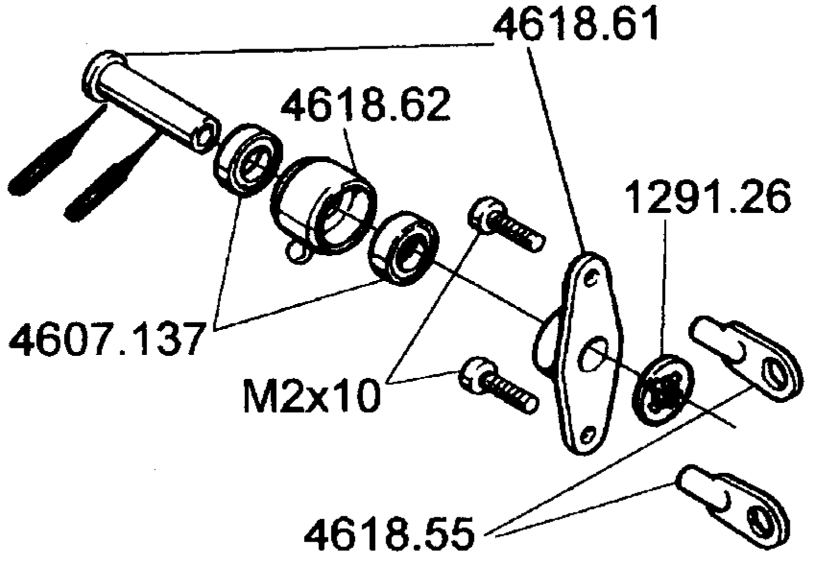
Fit a 3 mm Ø washer on the M3 x 22 socket-head cap screw, followed by the tail rotor bellcrank 4618.60.



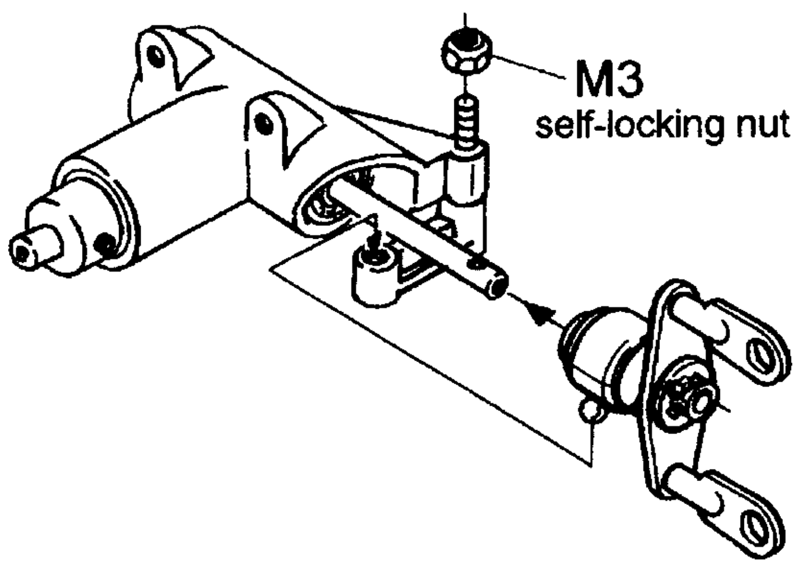
Check that the bellcrank rotates freely on the screw. If necessary de-burr the bore of the bellcrank and lubricate it with silicone oil. With the bellcrank on the screw, fit the screw in the hole in the shoulder of the tail rotor housing and tighten it by a few turns; do not secure it permanently at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

6. 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.

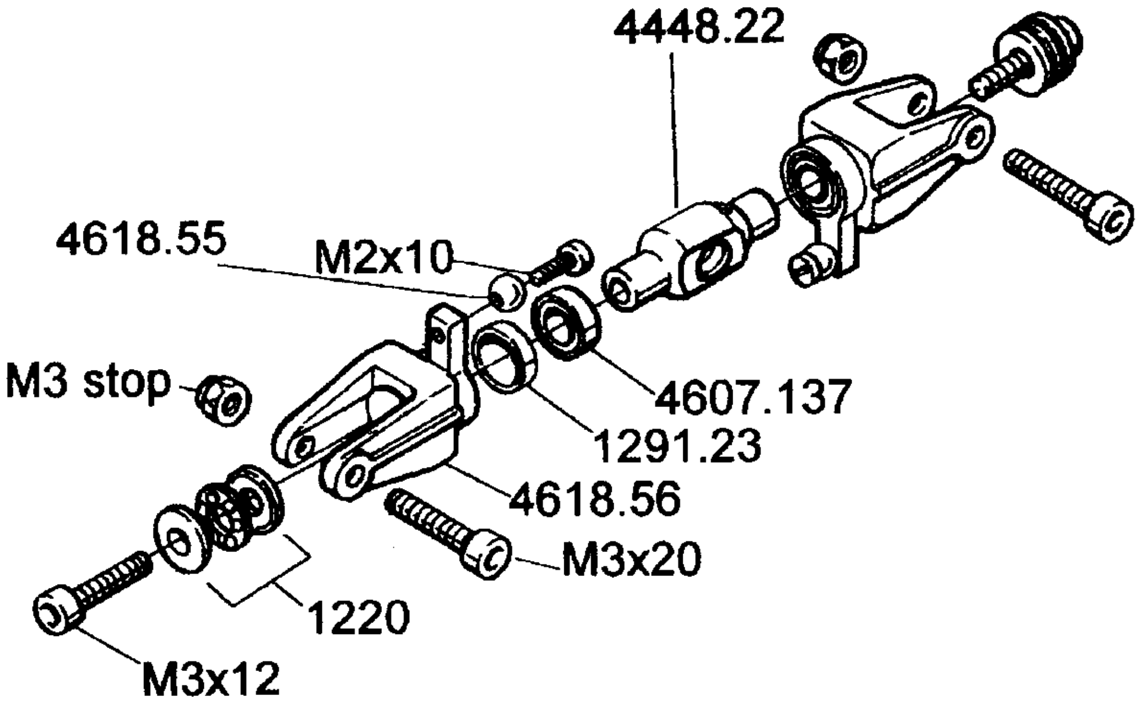


Fit the two ball-links 4618.55 on the control bridge 4618.61, slide it onto the control sleeve, and press it against the inner ring of the other ballrace. Press the shakeproof washer 1291.26 on the control sleeve and against the control bridge.
Check that the control ring can rotate easily on the control 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.



7. 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.

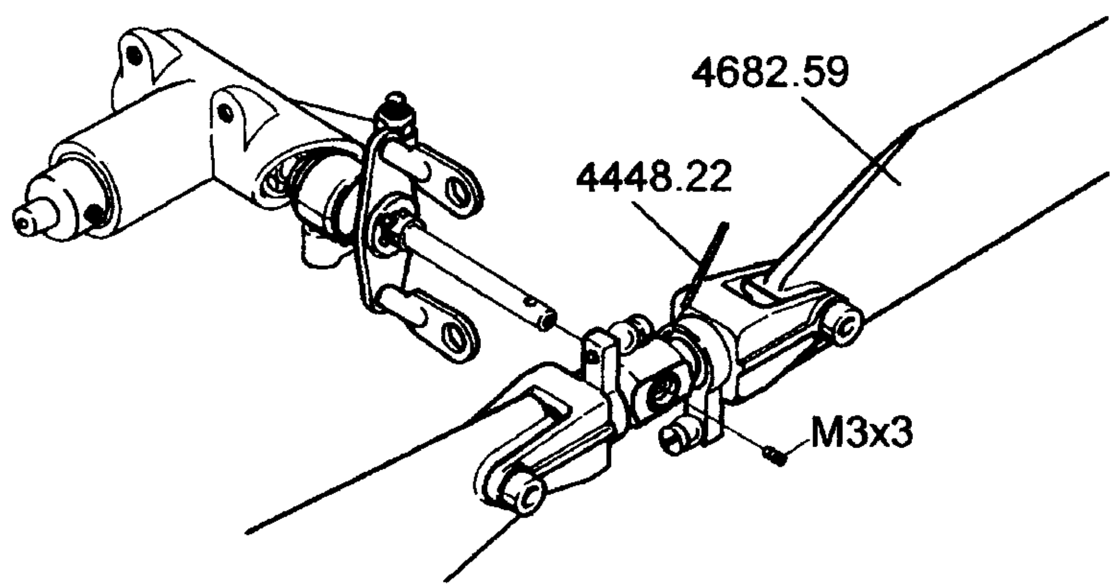


Place the two O-rings in the hub 4448.22 and press them into the channels. Oil the O-rings, fit the tail rotor head on the tail rotor shaft, and line up the cross-hole in the shaft accurately with the hole in the hub, and press the pin 4448.22 into place to fix the parts together. The pin is secured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

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

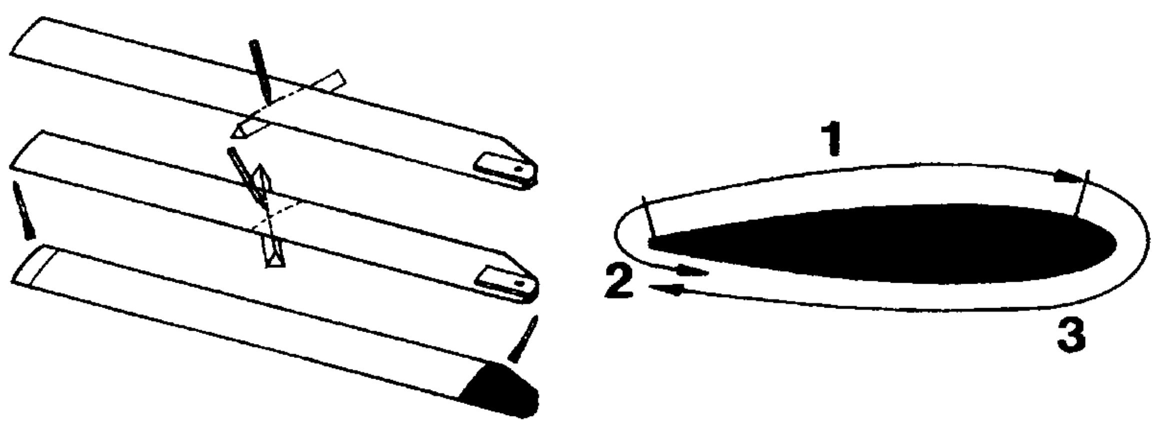
Fix the tail rotor blades in the blade holders using the two M3 x 20 screws. The tail rotor blade fixing screws must not be over-tightened; the blades should just be free to swivel, so that they can align themselves in the optimum position when they spin up to speed.

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.

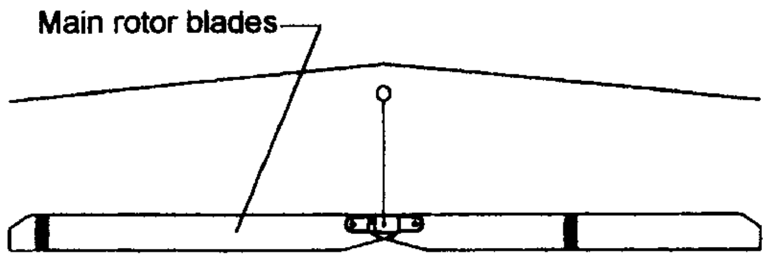


8. Main rotor blades

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!



8.1 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.

9. Installing the mechanics in the fuselage

You can install the mechanics in one of the many separately available fuselages, or complete the model as an open-style trainer. In either case follow the instructions supplied with the fuselage kit.

10. Setting up

10.1 Setting up the cyclic control system

The basic settings of the roll and pitch-axis control systems should already be correct if you have fitted the pushrods exactly as described in these instructions. The pushrod linkage points on the servo output arms are pre-defined, so any servo travel adjustment required must be carried out via the transmitter's electronic adjustment facilities. Please note that servo travel must not be set at too high a value; the swashplate must not foul the main rotor head when the roll and pitch-axis stick is at its end-points, as this would mean that smooth collective pitch control would no longer be possible, since the swashplate could not move any further along the shaft.

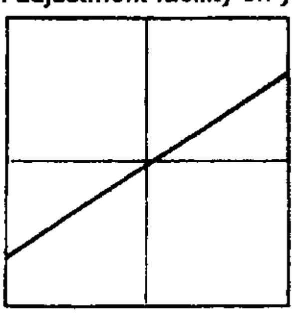
10.2 Main rotor collective pitch settings

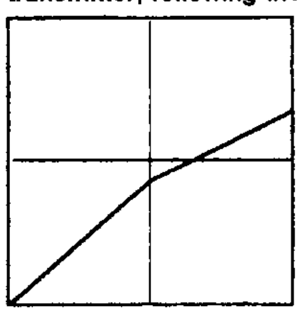
The collective pitch values are measured using a rotor blade pitch gauge (not included in the kit). The following table shows good starting points; the optimum values may vary according to the rotor blades you are using and the model itself.

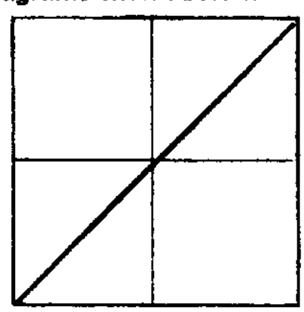
	Minimum	Hover	Maximum
Hovering, practice flying	-2°	5,5°...6°	12°
Aerobatics	-4°	5°... 5,5°	8°... 9°
Auto-rotation	-4°	5,5°	13°

The collective pitch settings are adjusted at the transmitter. This is the procedure:

1. Measure the setting for hovering collective pitch and set it correctly;
2. Measure collective pitch maximum and minimum, and adjust the values using the collective pitch adjustment facility on your transmitter, following the diagrams shown below:

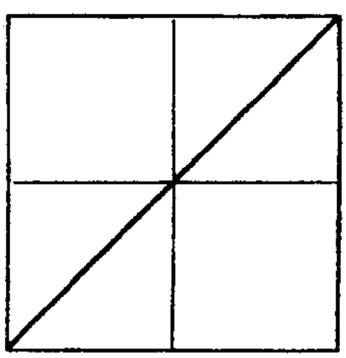

Hovering, practice
(linear)

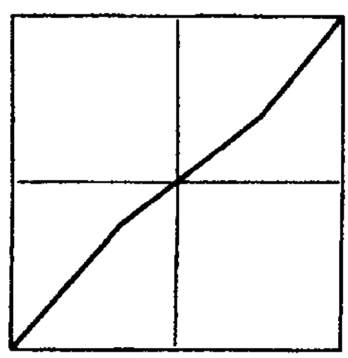

Aerobatics


Auto-rotation

10.3 Adjusting the carburettor control system

The following diagrams show two possible carburettor control curves:

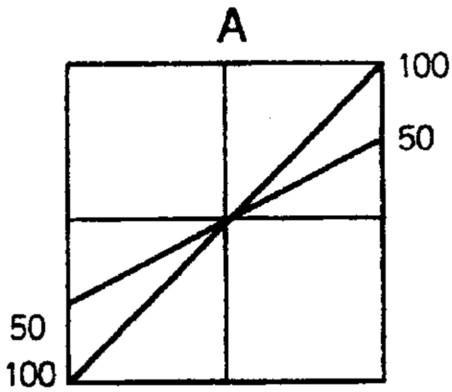

linear


optimised for hovering

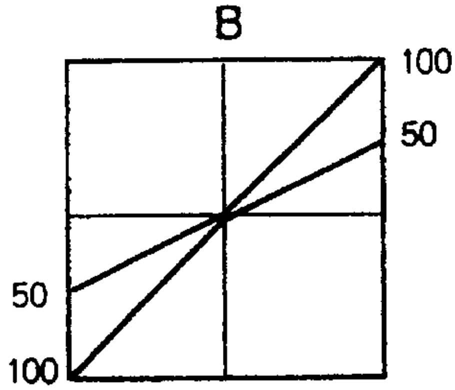
- The hover-optimised throttle curve produces smooth, gentle control response in the hovering range.
- The values stated here vary greatly according to the motor, fuel, silencer etc. you are using. The only means of establishing the ideal settings is to carry out your own series of practical test-flights.

If you have made up all the linkages exactly as described in the previous sections, 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, 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 travel 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 adjustment**
   This is where you can adjust the maximum servo travel. Note that the travels should always be the same on either side 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. with the same values for both directions, and that the throttle servo can move 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 arms, move them round by one spline and fit the retaining screws 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 much more difficult to get right!

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 page 38, 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 effect (gain), and switch between them from the transmitter via a supplementary channel. Some gyros even offer proportional control of the gain setting. The extra channel is controlled via a proportional slider or rotary knob, or a switch, depending on the gyro system.

If your gyro system features an adjustor box with two rotary pots for two fixed gain 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 gain 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 settings, as so many different influences affect the settings.
The aim of the gyro adjustment process is to achieve as high a level of gyro stabilisation as possible, without the system causing the tail boom to oscillate.

Notes regarding the use of the Graupner/JR „PIEZO 450...5000" piezo gyro system in conjunction with a computer radio control system (e.g. mc-12 ... mc-24)

The advanced design of this gyro system necessitates a different set-up procedure to the one described above. Please keep strictly to this procedure:

1. 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 gyro gain 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 limiting).
5. Connect the tail rotor pushrod to the servo in such a way that the tail rotor's mechanical end-points in both directions are the same as the travel set by the travel limiter (servo should be just short of stalling on its mechanical end-stop at this point).
   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 travel centre adjustment facility at the transmitter.
7. Gyro gain can now be adjusted between „0" and maximum effect via the auxiliary channel only, using a proportional control on the transmitter. If required, maximum gain can be reduced by adjusting the travel of the auxiliary channel or by adjusting the transmitter control. This gives you a useful range of fine adjustment for tailoring gyro response to your requirements.
8. If you find that the tail rotor control system is too responsive for your tastes, adjust it using the exponential control facility; on no account reduce servo travel, as it must be left at +/-100%!

11. Pre-flight checks

When you have completed the model, run through the final checks listed below before carrying out the helicopter's first flight:

- Study the manual once more, and ensure that all the steps of assembly have been carried out 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? Are the servo output arm retaining screws in place and tight?
- 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. 3157) to check the state of the receiver battery when you are at 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 widely 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.

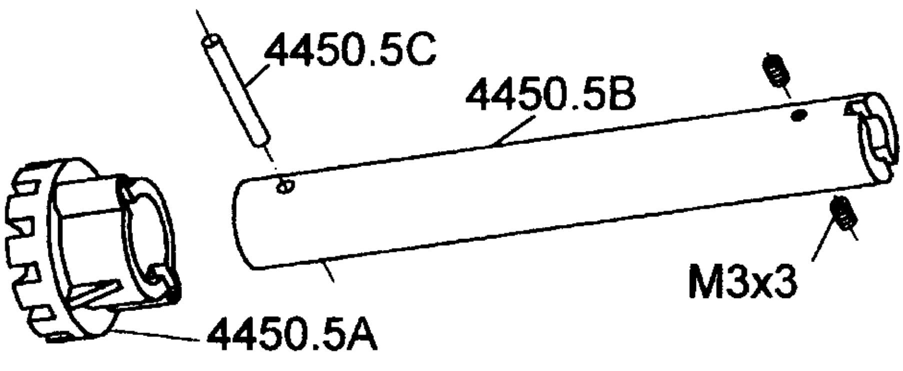
Maintenance

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 have to be fitted to your electric starter as shown in the drawing below. First insert the pin 4450.5C through the extension 4450..5B, then push the plastic adaptor 4450.5A on it, and engage the pin in the channel of the adaptor. To mount the starter adaptor you first have to remove the rubber insert holder from the starter. Push the starter adaptor onto the starter shaft until the cross-pin in the shaft engages in the channel of the adaptor. Tighten the two grubscrews fully to secure the adaptor.

Ensure that the adaptor runs „true", i.e. does not wobble from side to side.



To start the motor rotate the rotor head until the starter adaptor can be engaged in the cooling fan, holding the starter vertical. Please note the following points:

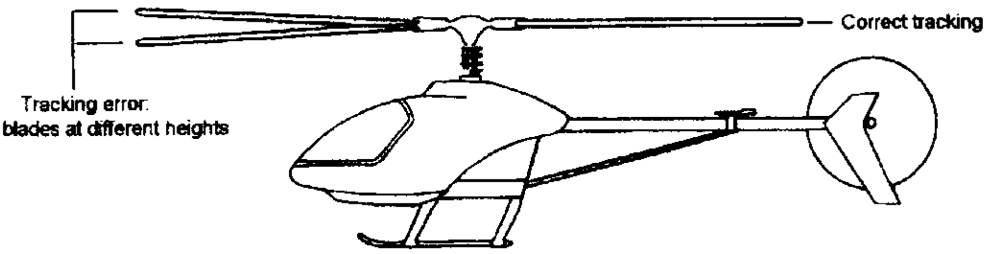
- **Do not switch the starter on until you are sure that the teeth in the cooling fan are correctly engaged with the teeth on the adaptor.**
- **When the motor is running, switch off the starter before withdrawing it.**

12. Adjustments during the first flight

12.1 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. In the interests of safety you should keep at least 5 metres away from the model when you are doing this.

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 tips.

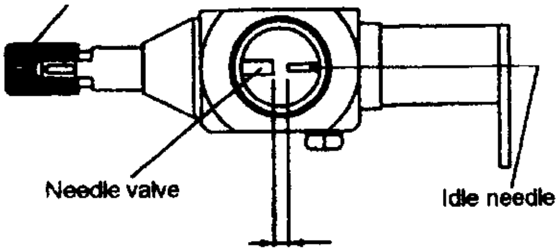
Procedure for adjusting blade tracking

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 clearly 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 (4618.150); 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.

12.2 Adjusting the motor

Please be sure to read the operating instructions supplied with your motor before you start this section.

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 rotational speed intended, 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 hovering collective pitch value exactly as described earlier in these instructions, then match the motor settings to that.
Although most motors nowadays are supplied with the carburettor factory-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 teeth 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 needle valve setting. Carefully close (screw in) the idle needle until the motor runs smoothly at hover, without any tendency to cut due to an excessively rich 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 made 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.

13. General safety measures

- Take out adequate third-party insurance cover.
- Wherever possible join the local model flying club.

13.1 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.

13.2 Pre-flight checks, flying safety:

- Before you switch on the transmitter check carefully that no other model flyer is using the same frequency.
- Carry out a range check with your RC system.
- Check that the transmitter and receiver battery 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.

13.3 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.

14. Some helicopter basics

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.

14.1 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.

14.2 Collective pitch

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

14.3 Torque compensation

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

14.4 Hovering

This is the state in which the helicopter flies in a constant altitude in a fixed position in the air, or moving only slowly in any direction.

14.5 Ground effect

Ground effect is a phenomenon which only occurs 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 a fixed obstacle (the ground) and forms an „air cushion". In ground effect a helicopter can lift more weight, but its positional stability is reduced, with the result that it tends to „break away" unpredictably in any direction.

14.6 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, i.e. one 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.

14.7 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.

14.8 Descent

If the helicopter's rotor speed is relatively low and you place the helicopter in a fast vertical descent, the result may be that insufficient air flows through the rotor. This can cause what is known as a „turbulence ring", i.e. 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.

14.9 Flapping motion of the rotor blades

As we have already seen, the forward-moving blade produces greater upthrust than the other blade. This effect can be minimised by allowing the forward-moving blade to rise and the other 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 a good solution to the problem.

14.10 Auto-rotation

This term refers to a helicopter flying 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.

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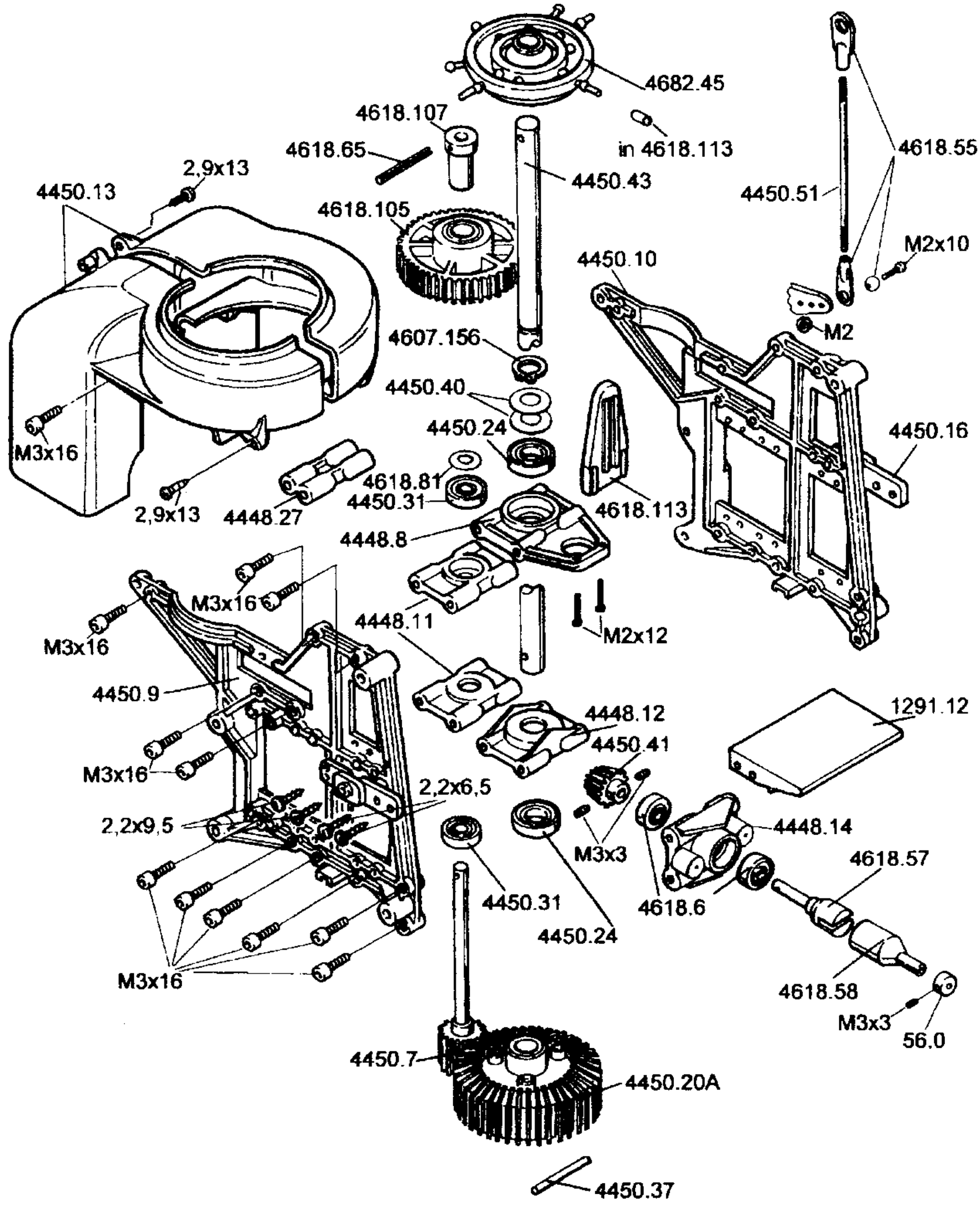
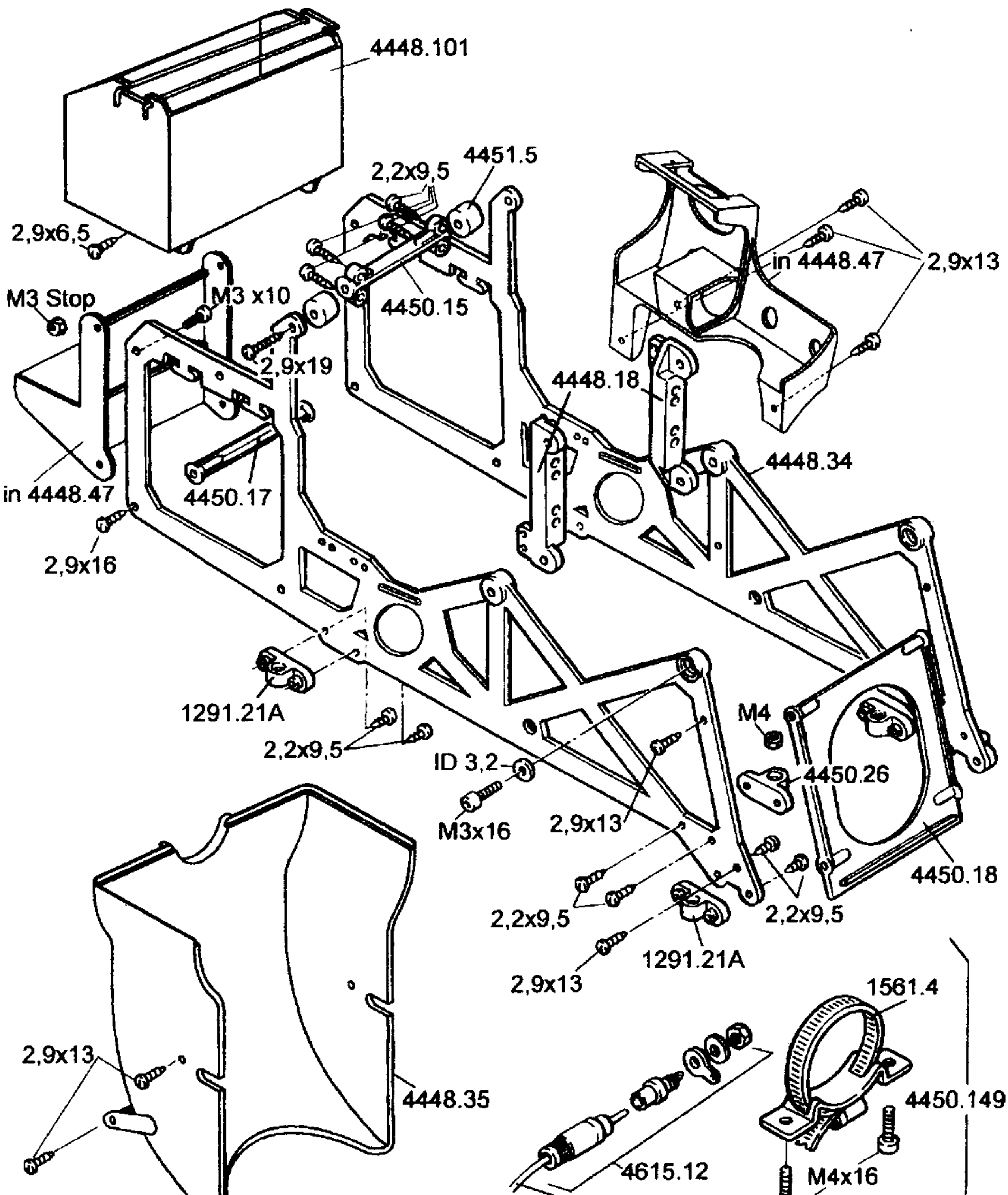
GRAUPNER GmbH & Co. KG D-73230 KIRCHHEIM/TECK GERMANY

Main gearbox



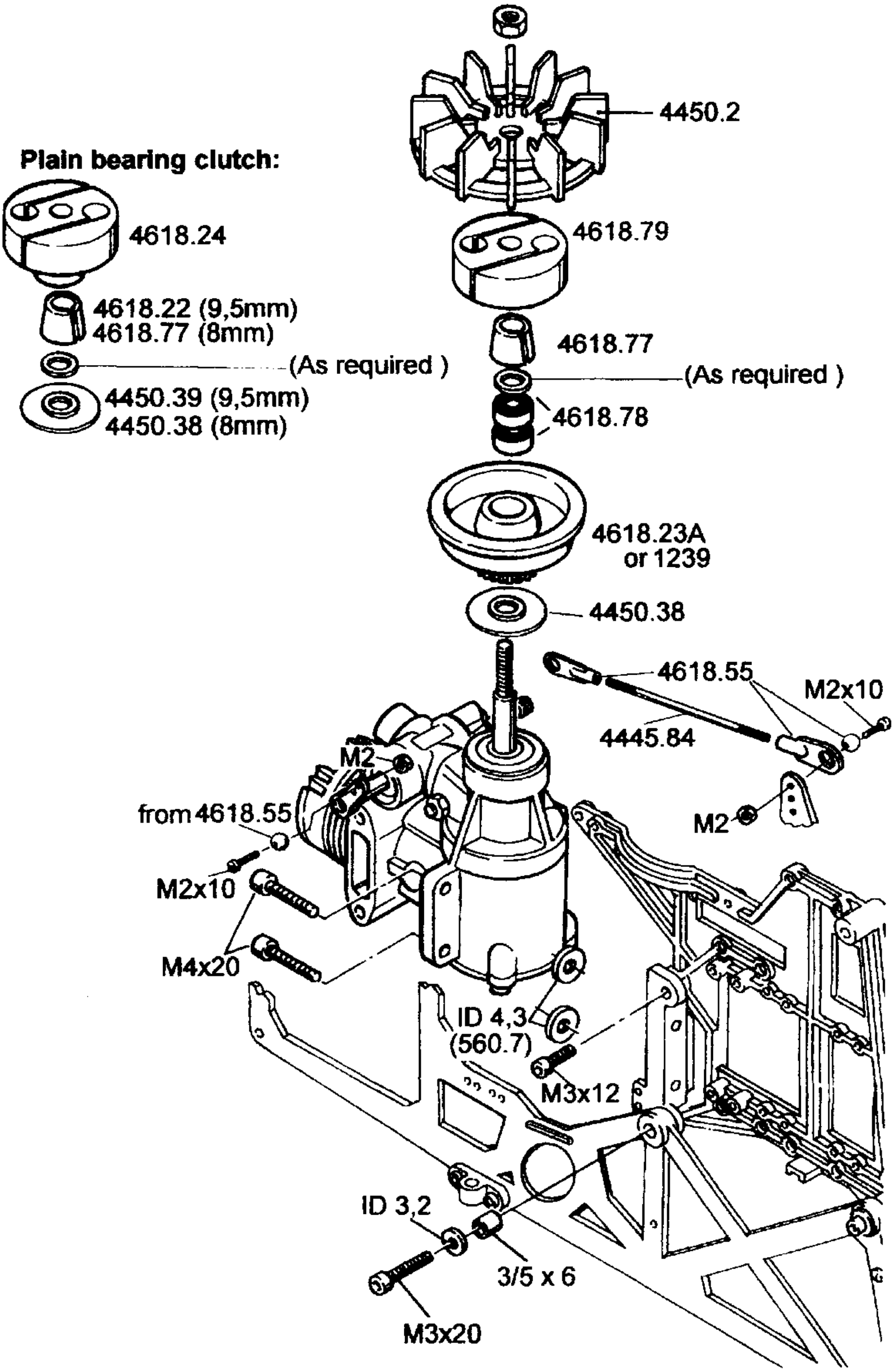
Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
1291.12	Gyro platform		1
4448.8	Dome bearing holder		1
4448.11	Layshaft bearing holder		2
4448.12	Main rotor shaft bearing holder		1
4448.14	Tail rotor drive bearing holder		1
4448.27	Spacer, short		1
4450.7	Shaft and pinion		1
4450.9	Mechanics side frame, L.H.		1
4450.10	Mechanics side frame, R.H.		1
4450.13	Fan housing, 2-part		1
4450.16	Gyro platform holder		2/2
4450.31	Ballrace	6/16x5	2/1
4450.20A	Ring gear		1
4450.37	Dowel pin	3Øx28	1
4450.24	Ballrace	10/19x5	2/1
4450.40	Shim washers for main rotor shaft	10/16 x 0,1/0,2	3 each
4450.41	Pinion		1
4450.43	Main rotor shaft		1
4450.51	Pushrod	2x75	3
4607.156	Circlip	Ø 10	1
4618.6	Ballrace	4/13x5	2/1
4618.55	M2 ball-links balls		6/10 2/10
4618.57	Shaft and yoke		1
4618.58	Quick-release coupling sleeve		1
4618.65	Roll pin	2x16	1
4618.81	Shim washer	6/12x0,1/0,2	2 each
4618.105	Plastic gear and freewheel	Ø 55	1
4618.107	Freewheel sleeve		1
4618.113	Swashplate guide Brass sleeve for swashplate guide		1 1
4682.45	Swashplate		1
56.0	Collet (tail rotor drive shaft)	2,1/6x4,5	1/10
565.16	Socket-head cap screw	M3x16	24 / 20
746.13	Self-tapping screw	2,9x13	4 / 20
747.7	Self-tapping screw	2,2x6,5	4 / 20
747.10	Self-tapping screw	2,2x9,5	4 / 20
704.10	Cheesehead screw	M2x10	2 / 20
704.12	Cheesehead screw	M2x12	2 / 20
107	Grubscrew	M3x3	3 / 10
710	Hexagon nut	M2	2 / 20
	Optional parts (not included in set)		
4450.46	Ring gear, special material, red		1
1234	All-metal swashplate		1

Bottom structure



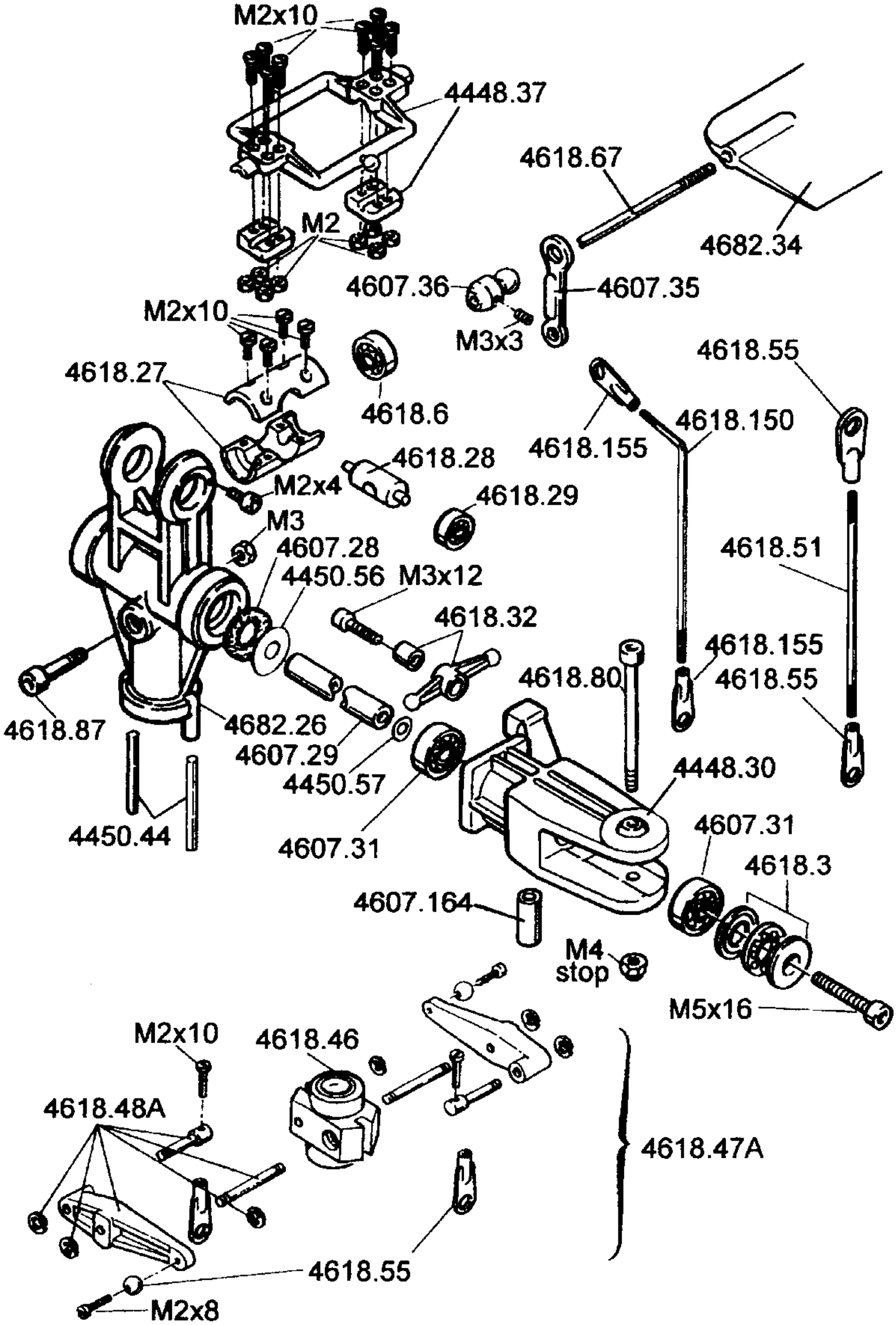
Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
1291.21A	Skid bracket, plastic		4 / 1
4448.18	Motor mount		2
4448.34	Side frame, front structure		2 / 1
4448.35	Air duct		1
4448.47	**Holders for battery, switch, etc.,** consisting of:		1
	Battery holder		1
	Holder for switch, glowplug socket and fuel valve		1
746.13	Self-tapping screw	2,9x13	3/20
565.10	Socket-head cap screw	M3x10	2/20
713	Self-locking nut	M3	2/20
	Cable tie	3,4mm x 140	4
4448.101	RC box		1
	Self-tapping screw	2,9x6,5	2
4450.15	Front structure adaptor, plastic		1
4450.17	Spacer, long		1
4450.18	Tail bulkhead, plastic		1
4451.5	Spacer, plastic	8/3x8	2
4615.12	Glowplug connector		1
3532	Twin flex cable		1
746.13	Self-tapping screw	2,9x13	6 / 20
746.16	Self-tapping screw	2,9x16	2 / 20
746.19	Self-tapping screw	2,9x19	2 / 20
747.10	Self-tapping screw	2,2x9,5	12 / 20
565.16	Socket-head cap screw	M3x16	2 / 20
560.6	Washer	ID 3,2	2 / 10
	Optional parts (not included in set)		
4450.149	**Silencer support set**, consisting of:		
1561.4	Clip		1/3
	Console		1
4450.26	Tuned pipe bracket, plastic		2
729.16	Cheesehead screw	M4x16	2/20
617	Self-locking nut	M4	2/20
747.10	Self-tapping screw	2,2x9,5	4/20

Motor, clutch, fan



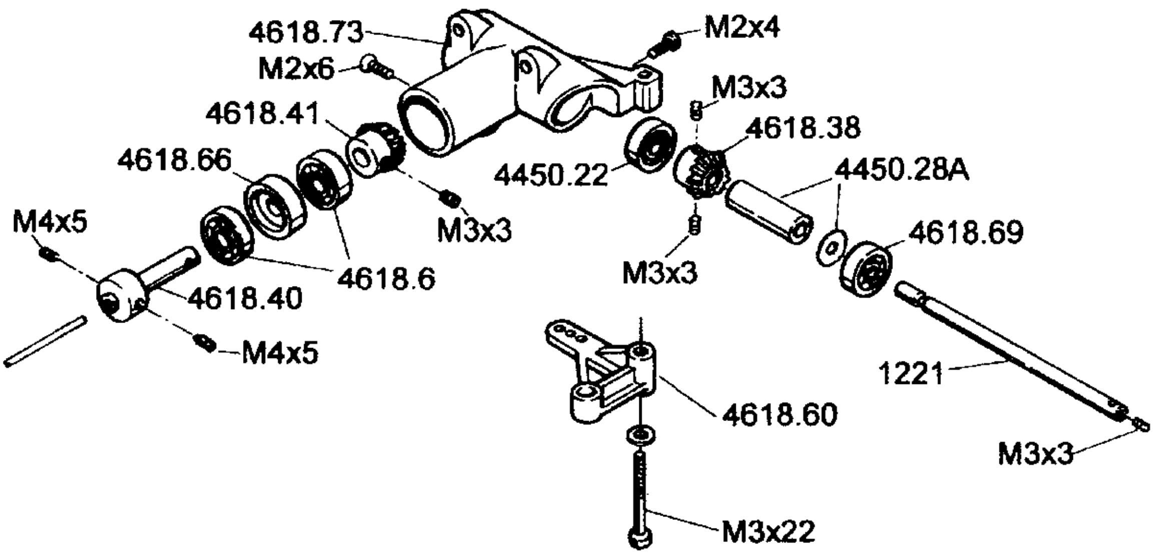
Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
4450.2	Fan		1
4450.34A	Brass sleeve	3/5x6	2 / 2
4450.38	Stepped washer	8mm I.D.	1
4618.23A	Clutch bell, 22-tooth (1:10 reduction)		1
	or:		
1239	Clutch bell, 24-tooth with lining, (1:9 reduction)		1
560.7	Washer	9/4,2x0,8	4
4618.77	Split taper collet, brass	8mm I.D.	1
4445.84	Throttle pushrod	2Ø x 45	1
4618.55	Ball-link, M2, with ball		2
4618.78	Ballrace for clutch	8/16x6	2
4618.79	Clutch, steel, for ballraced clutch bell		1
566.20	Socket-head cap screw	M4x20	4 / 20
565.12	Socket-head cap screw	M3x12	2 / 20
565.20	Socket-head cap screw	M3x20	2 / 20
704.10	Cheesehead screw	M2x10	2 / 20
710	Nut	M2	1 / 20
560.6	Washer	ID 3,2	2 / 10
	As required:		
4450.58	Spacer washers for taper collet	8/13x0,5 9,5/13x0,5	1 1
	Required for motors without "HEIM" crankshaft (not included in set)		
4618.22	Split taper collet, brass	9,5mm I.D.	1
4618.24	Clutch, steel, plain bearing		1
4450.39	Stepped washer	9,5mm I.D.	1
	Optional parts: (not included in set)		
4448.122	Metal clutch with lining 22 teeth		1
4448.124	Metal clutch with lining 24 teeth		1
4448.79	Clutchshoe, steel, for 4448.122/124		1
4448.77	Split taper collet, brass, for 4448.79		1

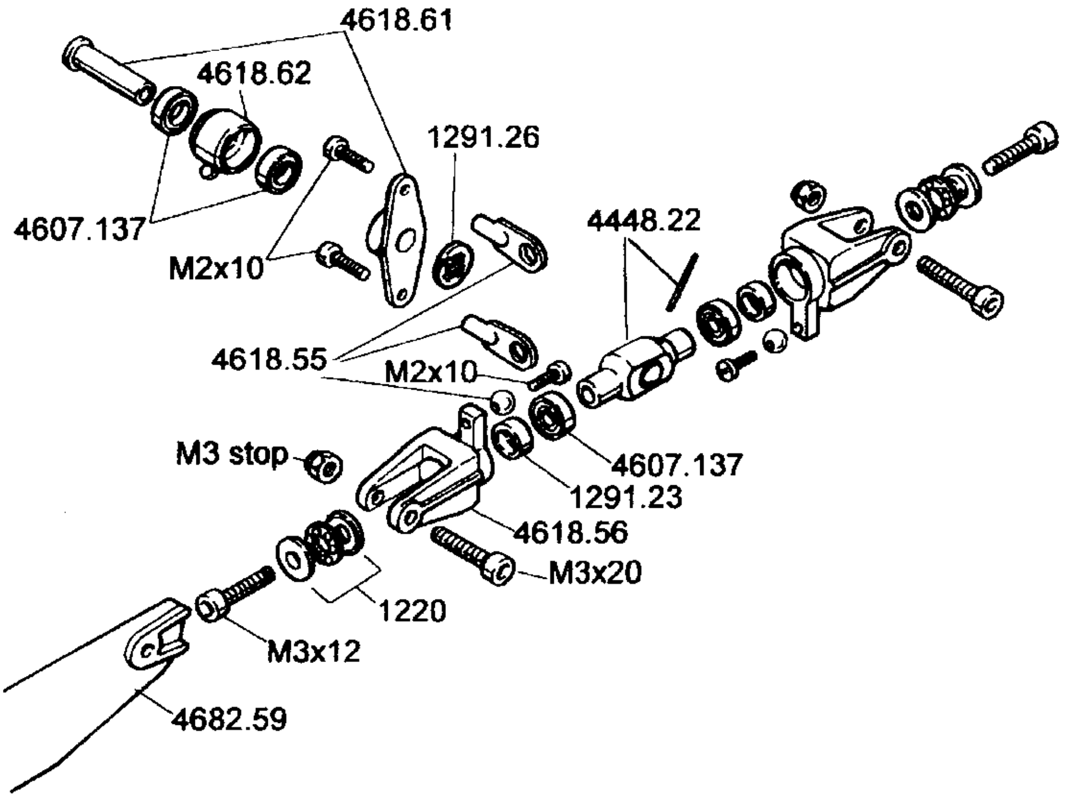
Main rotor head and collective pitch compensator



Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
4448.37	Control bridge, 3-part		1
4448.30	Blade holder		2/1
4450.44	Steel pin	2x28	2
4607.28	O-ring	8/14	2
4607.29	Blade pivot shaft		1
4607.31	Ballrace	8/16x4	4/1
4607.35	Double link, plastic		2
4607.36	Ball collet, brass		2/1
4607.164	Rotor blade socket		2
4618.3	Thrust bearing set, consisting of: Bearing shell, flanged Bearing shell, flat Ball bearing cage		 2 2 2
4618.6	Ballrace	4/13x5	2/1
4618.27	Rocker, 2-part, plastic		1
4618.28	Pivot pin, steel		1
4618.29	Ballrace	3/10x4	2/1
4618.32	Mixer lever, plastic with brass bush	 4/3x6,1	2 2
4618.46	Collective pitch compensator body, plastic		1
4618.47A	Collective pitch compensator, complete		1
4618.48A	Collective pitch compensator arm, plastic Bored pin, brass Brass pin Shaft retainer		1 1 1 3
4618.51	Straight pushrod	2mm	2
4618.55	M2 ball-link Brass linkage ball		6/10 2/10
4618.67	Flybar		1
4618.80	Special socket-head cap screw	M4x35	2
4618.87	Special socket-head cap screw	M3x18	1
4618.150	Pre-formed pushrod	2,5mm	2
4618.155	M2.5 ball-link (excl. ball)		4/10
4682.26	Rotor head centre piece		1
4682.34	Hiller paddle		2
704.4	Cheesehead screw	M2x4	2 / 20
704.8	Cheesehead screw	M2x8	2 / 20
704.10	Cheesehead screw	M2x10	14 / 20
107	Grubscrew	M3x3	2 / 10
565.12	Socket-head cap screw	M3x12	4 / 10
567.16	Socket-head cap screw	M5x13	2 / 10
710	Nut	M2	8 / 20
712	Nut	M3	1 / 20
617	Self-locking nut	M4	2
	As required:		
4618.82	Shim washer (play adjustment, blade holder)	8/16x0,3	5
4450.57	Spacer washer, brass	5/8x0,5	5
	Optional parts: (not included in set)		
4682.29	Blade pivot shaft (hard)		1

Tail rotor


4618.73
M2x4
M2x6
M3x3
4618.41
4618.38
4618.66
4450.22
4450.28A
M4x5
M3x3
4618.69
4618.6
M3x3
4618.40
M4x5
1221
4618.60
M3x3
M3x22


4618.61
4618.62
1291.26
4607.137
M2x10
4448.22
4618.55
M2x10
M3 stop
4607.137
1291.23
4618.56
M3x20
1220
M3x12
4682.59

Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
1220	Thrust bearing set, consisting of: Flanged washer Plain washer Ball cage		 2 2 2
1221	Tail rotor shaft		1
4607.137	Ballrace	6/10x2,5	4/1
1291.23	Spacer sleeve	10/8,5x 2	2
1291.26	Shakeproof washer		1/5
4448.22	Swinging tail rotor hub Pin	 2 Ø x18	1 1
4450.22	Ballrace	5/13x4	1
4450.28A	Spacer sleeve Shim washer	5/6x17 5/10x0,1	1 2
4618.6	Ballrace	4/13x5	2/1
4618.38	Bevel gear	ID 5	1
4618.40	Shaft and coupling		1
4618.41	Bevel gear	ID 4	1
4618.56	Blade holder, tail rotor		2
4618.60	Bellcrank, plastic		1
4618.61	Control sleeve, brass control bridge, plastic		1 1
4618.62	Control ring with ball		1
4618.66	Spacer sleeve, plastic		1
4618.69	Ballrace	5/13x5	1
4618.73	Tail rotor housing		1
4682.59	Tail rotor blade		2
4618.55	M2 ball-link with ball		2 / 10
704.4	Cheesehead screw	M2x4	1 / 20
704.10	Cheesehead screw	M2x10	4 / 20
565.12	Socket-head cap screw	M3x12	2 / 20
565.20	Socket-head cap screw	M3x20	2 / 20
565.22	Socket-head cap screw	M3x22	1 / 20
107	Grubscrew	M3x3	4 / 10
65	Grubscrew	M4x5	2 / 10
5882.6	Countersunk screw	M2x6	1 / 20
713	Self-locking nut	M3	2 / 20

Accessories (not illustrated)

Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
	Not illustrated:		
270	Fueltank, 570 ml		1
1648	Fuel filter		1
4450.5	**Starter adaptor**, consisting of:		
4450.5A	Starter adaptor, plastic		1
4450.5B	Starter extension		1
4450.5C	Cross-pin		1
3602	Threaded coupler	M2	1
3548	Clevis (tail rotor pushrod)		1
4618.55	M2 ball-link with ball (tail rotor pushrod)		2
76A	Rotor blade, straight	628lg	2
951	Loctite bearing-lock fluid 603		1
952	UHU-thread-lock fluid		1
544.0	Rubber band		4
1521.55	Cable tie		4
1643	Fuel tubing		1
3533	Crocodile clip (glowplug connector)		1
4450.200	Uni-Expert mechanics instructions, German		1
4450.201	Uni-Expert mechanics instructions, English		1
4450.202	Uni-Expert mechanics instructions, French		1

Optional parts: (not included in set)

Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
	Main gear:		
4448.79	Clutch		1
4448.77	Split taper collet, brass		1
4448.179	**Clutch remover**		1
567	Inbusschrauben	M5x20	2/20
4448.122	**Metal clutch** with lining		1
	Pivot, **22** teeth		1
	Ballrace		2
	Spacer		1
4448.124	**Metal clutch** with lining		1
	Pivot, **24** teeth		1
	Ballrace		2
	Spacer		1
4448.222	Replacement pinion, 22 Zähne		1
4448.224	Replacement pinion, 24 Zähne		1
4448.100	**Conversion set for main gear**, consisting of:		1
4448.140	Steel hub with freewheeling clutch		1
4448.141	Spur gear, 60 teeth, Delrin		1
565.10	Socket-head cap screw	M3x10	6/20
4448.142	Crown gear, 60 teeth, Delrin		1
4448.143	Crown gear flange, aluminium		1
565.8	Socket-head cap screw	M3x8	6/20
4448.43	Main rotor shaft		1
4448.156	Annular clamp		2
	Socket-head cap screw	M2,6x10	2
4448.21	Steel pin	3 Ø x20	1
4448.41	Bevel pinion		1
107	Grubscrew	M3x3	2
4448.113	Spaver for swashplate guide		1
5900.18	Socket-head cap screw	M2x18	2
4448.144	Steel spacer for layshaft	8/6 Ø x6	1
4450.40	Shim washer	16/10 Ø x0,1	3
4450.40	Shim washer	16/10 Ø x0,2	3
	Shim washer	16/10 Ø x0,5	3
4618.49	Spur gear, 54 teeth, plastic		1
4682.65	Piano wire pin	2 Ø x16	1
4618.81	Shim washer	10/6 Ø x0,1	2
4618.81	Shim washer	10/6 Ø x0,2	2
4448.104	**Sensor / magnet holder** for speed regulators		1

Graupner Order No.	Description	Dimensions [mm]	No. off reqd./pack
4448.26	Rotor head centre piece, Aluminium		1
4448.132	**Mixer lever with sideways mounted balls:**		1
4448.132A	Mixer lever		2
4682.6	Ballrace	7/3 Ø x 3	4
	Ball		4
	Washer	5/3 Ø x 0,6	2
	Spacer sleeve	5/3 Ø x 4	2
704.10	Cheesehead screw	M2x10	4/20
4448.135	**Double link** for 4448.132		2
4682.160	**Tail rotor bellcrank, ballraced**		1
	Replacement parts:		
4682.160A	Tail rotor bellcrank		1
4682.6	Ballrace	7/3 Ø x 3	2/2
4618.147	**Collective pitch compensator, ballraced**		1
	Replacement parts:		
4618.148	Collective pitch compensator lever		1
4618.129	Ballrace	7/3 Ø x 2	8/1
4448.102	**Conversion set for raised fuel tank**, consisting of:		
	Fuel tank holder		2
4450.17	Spacer, long		1
4451.5	Spacer	8/3 Ø x8	2
746.13	Self-tapping screw	2,9x13	2/20
746.19	Self-tapping screw	2,9x19	2/20
4448.103	**Hexagonal starting cone**		1
4450.149	**Silencer support set**, consisting of:		
1561.3	Clip		1/2
	Console		1
4450.26	Bracket, plastic		2
729.16	Cheesehead screw	M4x16	2/20
617	Self-locking nut	M4	2/20
747.10	Self-tapping screw	2,2x9,5	4/20