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MECHANIK

BELL 212 Twin-Jet

JOHANNES GRAUPNER · 7312 KIRCHHEIM/TECK · GERMANY

Building instructions

MECHANIK
BELL 212 Twin-Jet

Technical data

Powerplant: HB 61 STAMO glo engine 9.97 oc displ., with radial cooling fan

Gearbox: without oil sump, requires neither lubrication nor maintenance

Main rotor gear ratio: 9.928 : 1

Tail rotor gear ratio: 2.5 : 1

Contents of MECHANIK kit

Four ready-to-install sub assembly groups:

1. powerplant group
2. rotor head with collective pitch control
3. main rotor shaft
4. tail rotor gear box

The instructions include several ,,exploded views" to make things clearer. One of them is stapled to the center pages and is easily removable.

A supplementary set of instructions explains the assembly of the airframe (ZELLE), No. 4600.

Subject to changes serving technical advances and progress.

Printed in Germany

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Contents

1. Preface

The technical perfection of radio control equipment and model engines made the remote control and complete mastery of model helicopters a practical proposition back in 1967. But the highly sophisticated mechanical parts required for this new class of flying machine as compared to the much simpler fixed wing model permitted only a few modellers, lucky enough to have a precision machine shop and equipment at their disposal, to successfully build a model helicopter.

For a model helicopter not only a fuselage and R/C gear are required,. as in the case of the conventional model, but in addition a main rotor, tail rotor, with bearings for the rotating components is required, as is a reliable powerplant comprised of a combustion engine with gear boxes, an automatic clutch, a complicated main and tail rotor transmission system etc.

The MECHANIK kit for model helicopters markedly reduces the problems facing the model builder and eliminates potential sources of trouble. The mechanical parts of the drive system, consisting of engine, clutch, main rotor gear box, rotor shaft and blade control linkage, main rotor head and tail rotor gear box, are supplied fully assembled, tested and adjusted.

Only a carefully constructed BELL 212 TWIN JET model helicopter built exactly as per building instructions without any modifications whatsoever, will fly successfully and earn the modeller the well - deserved acclaim of his fellow modellers and spectators as well.

2. General

The box lid illustration shows a demonstration model of the BELL 212 TWIN JET R/C helicopter. This cutaway model differs in the arrangement of the various assembly groups from the one described in these instructions and is not representative of the layout of the operational machine. The illustrations and texts of the plan of the airframe kit ZELLE, No. 4600, show the correct installation of the mechanical assy. group, as well as that of the R/C gear.
Subject to change, in the interest of continual technical improvement (such as rotor blade hinging etc.)

The MECHANIK kit is specifically tailored for installation in the airframe of the BELL 212 TWIN JET R/C model helicopter assembled from the prefabricated kit No. 4600 ZELLE.

The mechanical parts of the MECHANIK kit may however also be used to advantage in other types of R/C model helicopters. In such a case the installation of the various mechanical parts must be left to the modeller's ingenuty, who should in any case carefully observe the recommended safety precautions mentioned later.

For best results, however, use of kit No. 4600 is expressly recommended.

The mechanical components of the MECHANIK kit are installed along with the assembly of the airframe (ZELLE kit No. 4600). For this reason do read and follow the instructions provided with both the MECHANIK and the ZELLE kits.

A supplementary plan for the installation of the mechanical parts is not required, as the illustrations and exploded views of the instructions for MECHANIK supply all the information needed. In addition the airframe plan shows the installation of the mechanical groups in the side view of the model by dotted outlines.

When you come across the symbol **Z** in the margins of the printed text this indicates that parts of the airframe have to be fitted and/or cemented in place before further components of the mechanical group(s) may be installed. In other cases it may indicate that some other work must be performed on the airframe or that reference to some other points of the airframe plan is made.

Numbers put in circles printed in the margins, such as **7** refer to the bag of the prefabricated kit ZELLE No. 4600 carrying the same code number. The relevant number-coded bag contains, among miscellaneous other things, the part required for the step in question. When capital letters are put in cireles, such as **B**, it means that the part in question is contained in the bag of miscellaneous parts supplied with the MECHANIK kit

Note to illustrations:

Several illustrations feature numbers put in circles. These numbers serve as an aid in locating relevant passages in the various instructions.

2.1. Additional preliminary remarks on the MECHANIK kit

Do not dismantle any parts of the MECHANIK kit, unless expressly specified in the building instructions.

Do not unscrew bolts unless prescribed in the building instructions for the step in question.

Under no circumstances should the bolts/mounting nuts (47) of the blade holders be unscrewed or loosened with a hexnut driver. These bolts/nuts serve to take the centrifugal forces encountered and must stay firmly tightened.

Be sure to carefully read the building instructions and those of the mechanical parts kit before tightening, loosening or mounting any of the various bolts, screws and other hardware or you may tamper with parts that should not be tampered with.

2.2. Proper treatment of ball links

The plastic parts of the ball link heads are precision made of high quality plastic material. They should not be removed from the balls unless required; in this case grasp the ringshaped part at both sides and pull them off.

Length of engagement of the threaded rod into the plastic part must not exceed 11 mm = 7/16", and must not be less than 5 MM = 13/64" either.

3. R/C helicopter models represent the „haute ecole" of modelbuilding

Be sure to observe the following points strictly:

3.1.
Success will only be achieved if the model is built according to plan. Follow instructions to the letter.

3.2.
Carelessness, construction and assembly mistakes will endanger the life of the pilot as well as that of spectators. The tips of the main rotor blades travel at speeds of up to 250 m.p.h., building up centrifugal forces on the order of some 280 lbs (that is the weight of two adults!).

3.3.
Beware of using damaged, bent and „repaired" parts again, they are potential sources of danger for you and other people.

3.4.
Use original spare parts only; this applies, in particular, to bolts and rotor blades.

3.5.
Be sure to follow maintenance instruction strictly.

3.6.
Use original ball bearings only to replace worn out ones. These ball bearings have been specifically selected for R/C model helicopter use and feature the proper bearing clearances, lubrication, seals, type of ball race cage, number of balls etc.

4. Particularly important hints

The following points must also be stressed and followed, in your own interest.

Some Do's and Dont's of R/C model helicopter operation you should know and observe.

4.1.
Do not fly your BELL 212 TWIN JET R/C helicopter model in populated areas, over people and crowds.

4.2.
Be sure to obtain adequate accident protection insurance. Your local insurance agent will be glad to provide information on the subject.

4.3.
The technical data of the model list a maximum all-up weight of approx. 14 lbs. 9 ozs. When the model reaches this weight, it exceeds the 5 kg (11 lbs. 6 ozs.) limit for model aircraft set by several countries and one **must** in such a case obtain permission for the operation of the overweight model helicopter from the appropriate domestic aviation authorities.

4.4. Note:
A compilation of the more important aspects pertaining to this theme are covered by the German language brochure „Modellflug und Luftrecht" prepared by Berthold Petersen and published by Johannes Graupner of 7312 Kirchheim/Teck, Germany. This brochure should be available from your local dealer.

5. Technical data

of MECHANIK kit for the BELL 212 TWIN JET R/C model helicopter

Gear ratio of main rotor gear box	9.928 : 1, without oil sump; requires neither lubrication nor maintenance
Gear ratio of tail rotor gear box	2.5 : 1
	HB 61 STAMO glo engine with radial cooling fan

6. Preliminary installation of the mechanical parts into the fuselage

The assembly of the airframe (ZELLE) has been completed up to the stage described in the building instructions ZELLE to p.

Be sure to check off all points of the building instructions once they have been finished. In this manner you won't forget and unintentionally skip one of the steps. Use the building instructions for a check list.

6.10. Installation preliminaries

6.11.
Clean and sweep workshop and bench prior to unpacking the MECHANIK parts kit. Otherwise sand, grit or filings may spoil the mechanical parts or the engine.

6.12.
Remove muffler from engine.

6.13.
Seal exhaust and intake openings of engine with pressuresensitive tape (such as masking or scotch) against dust.

6.14.
Remove the large plastic bevel gear (4). Proceed as follows:

6.14.1.
Remove the M 3 x 8 socket head screw (1) retaining the shaft part (2)

6.14.2.
Pull part (2) from intermediate bearing (3)

6.14.3.
The large plastic bevel gear (4) may now be removed.

6.14.4.
Also remove aluminum shaft of bevel gear (4). This shaft is no longer required.

6.14.5.
Save the aluminum tube (5), this will be used in a later phase of the assembly.

6.20. Preliminary installation of the MECHANIK parts
6.21.

6.20. Preliminary installation of the MECHANIK parts

6.21.
Insert the power unit in the engine compartment of the helicopter, as per side view on plan (dotted lines). Be sure to remember that the engine is installed inverted.

6.22.
Bearing plates (6/7) of the power unit should be installed flush with the front end of the foundation cemented in the fuselage. It should also rest snugly on rails (114) at both sides.

6.23.
Mark positions of holes for the mounting bolts, five on each side, with a sharp pencil.

6.24.
Remove MECHANIK parts and center punch the holes.

6.25.
Drill holes for the M 4 blind nuts (163) at these stations, using the ultra-long drill bit provided for the purpose.
Attention! Do not use the power unit as a template when drilling the holes.

6.26.
Install blind nuts M 4 in the drilled holes in the two longitudinal formers (112/113) and cement them in position with UHU - plus „endfest 300".

6.27.
Cover holes in vertically arranged longitudinal formers with heavy quality Japanese tissue paper. Fuel-proof the latter by a coat of SPANNFIX later.

6.28.
Insert the power unit and bolt into place. Use M 4 x 20 bolts and lock washer.

6.29.
Attach needle valve extension. Proceed as described in operating instructions of engine. Solder a length of 3/64" Ø steel wire and the turned brass part supplied with the engine accessories, to the needle valve.

6.30 Preliminary installation of the main rotor shaft

6.30.1.
Remove all parts slipped onto the main rotor shaft (8) and store them in a dust-proof plastic bag.

6.30.2.
Slip the main rotor shaft (8) into bearing (9) of the power unit, with the upper end protuding from the 1/2"Ø hole at the fuselage top.

6.30.3.
Check position of the main rotor shaft in the top 1/2"Ø hole of the fuselage. It should be positioned in the center of the hole. If it is not, the hole may be opened 5/64" (max.) to an oval shape.

If upon insertion of the rotor shaft, the ball bearing in the power unit (part 9) starts to bind something is wrong.
Check the following points:
position of hole at top of fuselage with respect to rear reference edge,
accuracy of installation of wooden frame in the fuselage.
Attention!
Do not, repeat not, try to re - position the power unit by inserting wood shims below it. This will only cause damage to the mechanical parts by spoiling their alignment. And it will also result in vibrations which, in turn, may render model, R/C gear and mechanical parts inoperative a short period of time. The power unit must be installed stressfree and sit flush on its base!

6.30.4.
Lift off the top rotor shaft bearing (10); seal bottom end with pressure - sensitive tape.

6.30.5.
Put a bead of UHU - plus „endfest 300" around the top hole provided for the main rotor shaft in the fuselage. The cement must not run into the hole.

6.30.6.
Slip top main rotor shaft bearing (10) onto the rotor shaft and press it against the cement bead forming a foundation for part (10) in the process.

6.30.7.
Align rotor shaft stress free, permit cement base for the rotor shaft bearing to set thoroughly.

6.30.8.
Then mark positions of holes for the top rotor shaft bearing (10).

6.30.9.
Remove top rotor shaft bearing (10) from main rotor shaft (8).

6.30.10.
Drill four 5/32" diam. holes for the M 3 blind nuts.

6.30.11.
Cement the four M 3 blind nuts (164) into place with UHU - plus „endfest 300".

6.30.12.
Bolt top bearing of main rotor shaft with hollow (Allen) screws M 3 x 8

6.30.13.
Remove and store the main rotor shaft.

6.40. Preliminary installation of the tail rotor transmission

6.41.
Thread steel wire (165) serving as tail rotor drive shaft through rear end of fuselage into stuffing box (161) and insert it in the bore of coupling (11) of the power unit, pushing it all the way in.

6.42.
Lightly tighten the six M 3 x 3 (4) set screws of coupling (11).

6.43.
Rotate intermediate shaft of power unit with tail rotor drive shaft attached to check for smooth operation. Also check shaft for proper alignment.

6.44.
Line up the stuffing box (161) at the power unit end in former (115) in such a manner that the tail rotor drive shaft (165) runs freely, without any tendency to bind.

6.45.
Then secure stuffing box (161) in position with cement.

6.46.
Unscrew the four M 3 x 3 (4). Allen set screws at the thicker section of coupling (11), then remove the latter from the intermediate shaft of the power unit, together with the tail rotor drive shaft clamped to it and store these parts.

6.50. Preliminary installation of the tail rotor gear box.

(Final installation is made after the trailing edge of the fin has been cemented in place) Drill four holes to accept the mounting bolts of the tail rotor gear box.

6.50.1.
Carefully align the gear box on brace (149), at right angles to both the vertical and the longitudinal axes. Mount with four self-tapping screws.

6.50.2.
Slip tail rotor drive shaft (165) into place from the power unit end and guide it into coupling (12) of the tail rotor gear box; push it all the way into the sleeve.

6.50.3.
Lightly clamp the tail rotor drive shaft in place with six M 3 x 3 Allen set screws.

6.50.4.
Check transmission for true running

6.50.5.
Carefully align the rear end of stuffing box (161) to ensure free running of the tail rotor drive shaft (165).

6.50.6.
Cement rear end of guide tube into place.

6.50.7.
Remove tail rotor drive shaft

6.50.8.
Remove tail rotor gear box.

6.50.9.
Remove power unit, from fuselage.

6.50.10.
Unscrew top main rotor bearing.

6.50.11.
Pack and store all parts in dustfree plastic bags.

6.50.12.
Continue assembly of fuselage, as per airframe building instructions ZELLE, p.

7. Final installation of power unit

7.1.
Install top main rotor bearing.

7.2.
Install power unit (incl. engine).

7.3.
Install throttle linkage; make sure that unrestriced travel is porvided from idle to full speed.

Attention!
The carburetor control linkage must move freely, otherwise the servo will be excessively loaded as it is also used for collective pitch control.

Important notice: All linkages must be installed to permit unrestricted full travel, (plus trim range) of all controls without any mechanical restraint.

This requirement is particularly important in the case of the throttle linkage. The two end positions, that is „full throttle" and „idle", must be determined by the position of the transmitter control stick only, not, repeat not, by a mechanical restraint, otherwise the servo will be subjected to full load throughout the entire flight, consume a lot of current and deplete the battery. The resulting voltage drop may cause malfunction of the entire R/C system.

Secure all threaded couplers in their respective clevises against unscrewing; use cement, solder or counter nuts.

7.4.
Make sure that the intermediate shaft of the power unit turns freely.

7.5.
Remove tape from exhaust port of engine, fasten muffler.

7.6.
Screw in needle valve.

8. Final installation of tail rotor gear box

8.1.
Re-install tail rotor gearbox, tighten screws. Do not slip shaft coupling (12) onto drive shaft (165) yet.

8.2.
Be certain that the driven shaft is at right angles to the vertical and longitudinal axes; check carefully, because the line-up may have been altered during installation of the trailing edge of the fin.

8.3.
Remove coupling (12) from the shaft of tail rotor gear box.

8.4.
Install tail rotor drive shaft (165) from the power unit end into stuffing box until it contacts the 1/8" diam. geor box shaft.

8.5.
Cut drive shaft (165) to proper length, leaving a gap of 3/64" between the end of the flexible drive shaft and the intermediate shaft of the power unit.

8.6.
Remove the tail rotor gear box; connect flexible drive shaft and tail rotor gear box by installing coupling (12). See that the drive shaft and the shaft of the tail rotor gear box are properly aligned.

8.7.
Tighten the ten set screws in coupling (12) lightly first, then tighten them firmly.

8.8.
Install the flexible drive shaft and gear box assembly from the rear end into the stuffing box.

8.9.
Mount the tail rotor gear box permanently with four selftapping screws 3/32"Ø x 1/2".

8.10.
Make sure that the flexible drive shaft does not butt against the intermediate shaft of the power unit. Fasten the drive shaft to the intermediate shaft by pulling the drive shaft a fraction of an inch out of the way, to permit slipping the coupling (11) onto the drive shaft (165) first and from there onto the intermediate shaft.

Attention! In case the tailrotor drive shaft (165) **cannot** be installed in the manner described because of assembly errors or similar reasons, the tailrotor transmission should be moved inside the guide tube (161) in such a manner that it is **under any circumstances** held and retained by the six set screws each of the two clutch sleeves (11) and (12).

8.11.
Tighten the ten set screws in the coupling lightly first at the intermediate shaft end, then tighten **all** set screws firmly.

8.12.
Check the flexible drive shaft for true and smooth running by rotating the shaft at the power unit end. The shaft must not jerk. If it does, it indicates a bent drive shaft.

Attention!
The steel wire serving as drive shaft (165) cannot be straightened. If bent it must be replaced by a new, perfectly straight length of steel wire. Wire spares available separately; ask for No. 4600/3, pack of 10 wires.

9. Final installation of the main rotor shaft

9.1.
Install the main rotor shaft (8) from the power unit end in such a manner that the shaft end with two holes faces the power unit.

9.2.
Slip on the aluminum spacer tube (5).

Attention!
Installation of this spacer tube is mandatory. If it is omitted the helicopter model will not be operative!

9.3.
Slip the large bevel gear (4) onto the main rotor shaft.

9.4.
Screw in the central socket head screws M 3 x 8 on the clamping ring of the large bevel gear. These central screws must engage the two holes in the main rotor shaft.

Attention!
These two central screws merely serve as positioners which ensure proper axial position of the bevel gear (4) on the rotor shaft. They represent an additional precaution against the rotor shaft loosening when subjected to the torque forces exerted by the large bevel gear. The screws, if used as drivers to transfer torque forces, would enlarge the holes in the rotor shaft to an oval shape. The resultant sharp edges would make removal of the rotor shaft from the bevel gear impossible.

9.5.
Tighten outer screws of the clamping ring firmly. Clamping the bevel gear onto the rotor shaft ensures proper transmission of torque reaction.

Attention!
In view of the elasticity and flexibility of the large plastic bevel gear (4) these screws must be tightened prior to each flying session.

9.6.
Install idler bearing (2) into the 5/32" diam. hole of the intermediate shaft housing (3). The ballrace which presses against the large bevel gear, serves as an idler bearing, and should be spaced 5/32" from housing (see fig. 2).

9.7.
Clamp shaft of idler bearing into place, using socket head screw (1) M 3 x 8.

9.8.
Check gearbox for smooth running. Backlash between the large bevel gear (4) and the bevel pinion (13) should be barely noticeable. Proper tolerance is obtained if the set screw M 4 x 20 with counter nut, positioned below slot, has not been re - set. In case of zero or excessive backlash, find out why. Possible causes are:

9.8.1. main rotor shaft not trued up as per building in structions (see,,Installation of main rotor shaft"),

9.8.2. spacer tube not installed,

9.8.3. set screw M 4 x 20 (14) with counter nut (15) of intermediate bearing not properly set.

10. Final installation of pitch control linkage

10.1.
Loosen counter nut M 6 (16) below aluminum bearing block (17) on the housing of the intermediate shaft bearing (9).

10.2.
Then remove the shoulder screw (18) and spring washer (19) from the bearing block.

10.3.
Install the pitch control rod (20) into the main rotor shaft (8) from the power, unit side. Remove socket head screw M 3 x 18, elastic stop nut and brass tube (21) from bearing head of pitch control rod.

10.4.
Now slip the slotted pitch plate (22) onto the pitch control lever (23).

10.5.
Install the pitch control lever (23) into the slot of the bearing head of the pitch control rod (20) in such a nammer that the pointed end of lever (23) passes through the slot of the wooden former (115) at the end of the engine compartment. The slotted pitch plate (22) must be positioned between rotor shaft (8) and former (115), on the pitch operating lever.

10.6.
Screw pitch operating lever (23) into bearing block (3) with shoulder screw (18), with spring washer (19) inserted between screw head and pitch operating lever in such a manner that the lever is pressed against the face of the bearing block (17).

10.7.
Check position of pitch control rod in main rotor shaft. The rod should rest in the rotor shaft without binding.

10.8.
Screw slotted pitch plate (22) to former (115).

10.9.
Secure threads of bearing block (17) on intermedinate shaft bearing housing (3) with M 6 counter nut.

10.10
Check concentric, stress-free installation of the pitch control rod (20) in the rotor shaft (8) once more.

10.11.
Install brass tube (21) into bearing head of pitch control rod, slip sacket head screw M 3 x 18 through brass tube, add elastic stop nut and tighten it moderately.

Attention!
The pitch control lever (23) must be perfectly straight (see fig. 4). Do not bend the lever in an attempt to provide a concentric, stress - free installation of the pitch control rod in the rotor shaft. A bent lever may cause an in-flight failure in operation of the collective main rotor pitch control by destroying the ball bearing in the bearing head of the pitch control rod.

11. Final installation of swashplate and drag link

11.1.
Slip swashplate (24) onto main rotor shaft from above.

11.2.
Provisionally clamp drag link (25) lightly with clamping screw M 3 x 25 and elastic stop nut. The screw is firmly tightened later when the control mechanism and the rotor head are adjusted.

11.2.
Then slip drag link (25) onto main rotor shaft (8)

12. Assembling the main rotor

12.1. Mounting the main rotor blades

The covered and balanced main rotor blades are inserted into the blade holders (26). If our advice to use dope sparingly and to sand the rotor blades thoroughly has been followed during preparation of the rotor blades the latter will write the pockets of the blade holders snugly. Carefully check proper fit of the blades in their pockets. For completion of main rotor blades see chapter 4.1. of airframe building instructions ZELLE.

12.2.
Install three socket head screws M 3 x 18 through the holes of the blade holders, with M 3 elastic stop nuts located on the top side of the holders.

12.4.
Check rotor blades for equal angular relationship of 180° for correct geometric balance. This is extremely important for smooth operation of the main rotor (see ill.). Check by running a thread from one rotor blade end to the other one, some 17/32" aft of the leading edge at both ends.
The thread must be carefully lined up with the center of the top bolt of the central body (34).

13. Balancing the main rotor

13.1.
Make sure that the main rotor hub (34) sits at right angles to the top edges of the bridge plates (37) of the rotor head. Adjustments can be made by moving the damper ,,O" rings (46) accordingly.

13.2.
Build an assembly jig from 5/64" plywood as per dimensioned diagram, fig. 7. Wood parts for the jig are contained in the airframe kit ZELLE No. 4600.

13.3.
Put rotor head with mounted main rotor blades and central part (34) in the assembly jig. The head can then be balanced in the jig, rotating about the lateral tenons of the hub (34), which protude from the aluminum bridge plates (37). The pitch control horn (28) stands level.

13.4.
Unbalance of the rotor blades, if excessive, is compensated by screwing self - tapping screws of max. 7/64" diam. into the leading edge of the tip of the lighter rotor blade. Self - tapping screws of various diameters are available from hardware stores.

Attention!
The screw must be screwed into the beech wood section of the blade and cemented firmly. Work with care; remember the centrifugal forces to which these parts are subjected.

13.5.
Slip rotor head onto rotor shaft (8). Guide the pitch control rod (20) into the yoke (27).

13.6.
Screw in the central M 3 x 8 socket head screw at the clamping ring of the main rotor hub (34). This screw must extend into the single hole in the main rotor shaft (8). The screw, by extending into the hole is used only to correctly position the main rotor head.

Attention!
This central M 3 x 8 screw at the clamping ring does not act as a driving member between rotor shaft and rotor head. Torque must only be transmitted by clamping the central part to the rotor shaft to provide a no - slip connection. If only the screw and hole were used to transmit torque, the hole would be deformed, causing a sharp edge to form which in turn would make removal of the rotor shaft impossible.

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13.7.
Firmly tighten the external screws at the clamping ring, thereby clamping the main rotor hub (34) to the main rotor shaft.

13.8.
Guide M 3 x 12 screw through the holes at the lower end of yoke (27) and screw it into the threaded hole M 3 in the pitch control rod before the M 3 x 12 screw can engage the threads. Tighten screw firmly.

13.9.
View assembly from above and check that rotor shaft (8), engaging lever (25) of the swashplate and link rod are positioned relative to each other as per diagram (fig. 8).

13.10.
Align the drag link (25) in such a manner that the long lever with ball-shaped head of the rotating part of the swashplate in positioned directly underneath the ball-shaped head of the pitch control horn (28) mounted on the servo rotor (30).

13.11.
Lift helicopter model at rotor head and press drag link (25) against swashplate.

13.12.
Firmly tighten clamping screw with elastic stop nut at drag link (25).

13.13.
Mount the ball head bolt with STOP nuts M3 (bag E) at the location indicated on the plan, and connect the tie rod from the stationary part of the swashplate to it.

13.14.
Connect pushrods between lateral and longitudinal cyclic pitch servos and the ball heads on the swashplate.

13.15.
Make sure that the swashplate is perfectly level when the servos are in neutral position. If it is not alter length of rods accordingly by turning the ball links to suit.

Attention!
Be sure to follow introductory remarks on the proper method of connecting and disconnecting the ball links, respectively.

14. Fitting the servo rotor blades to the rotor head

14.1.
Loosen set screw of collars (45) on the servo rotor shaft (29) of the see-saw hub (31) at the top of the rotor head. Do not detach the collars!

14.2.
Screw rods carrying the servo rotor blades (30) approx. 10 turns into the threads of the servo rotor shaft (29). Check uniform spacing of servo rotor blades to see-saw hub.

14.3.
Detach ball links from mixing levers (32) of see-saw hub (31). The latter, with servo rotor rods (30) and blades screwed into servo rotor shaft (29) is now able to oscillate freely.

14.4.
Balance the servo rotor system, using the see-saw hub bearing for a pivot. Unscrew rod of lighter servo rotor blade or screw in the rod of the heavier one.

14.5.
Make sure that all members of the servo rotor linkage are uniformly screwed in and deep enough for a firm hold.

Attention!
Each threaded rod must be screwed in at least 4 turns in the servo rotor shaft, otherwise the threads may fail when subjected to the centrifugal forces of the servo rotor blades.

If the prescribed number of turns (e.g. 4) prevents balancing the servo rotor properly, balance must be obtained by grinding off the tip of the heavier servo rotor blade.

14.6.
Servo rotor blade pitch angle should be zero. Check angle by viewing along blade in the direction of the servo rotor rod at rotor disk level.

Visually check position of the servo rotor blades relative to each other and adjust until parallel. The pitch control horn (28) should point upward at an angle of +5° when the servo rotor blades are set at 0° angle of incidence. See ill.

14.7.
Move set screws of collars (45) to a central position between the slots of the servo rotor shaft and tighten them (see il 10)

This serves to clamp the servo rotor rods in their proper positions.

14.8.
Reconnect the ball links to the mixing levers (32) of the see-saw hub.

14.9.
Install pushrod between swashplate and ball link of the pitch control horn (28) of the servo rotor.

14.10.
With the swashplate in horizontal position the servo rotor pitch angle should be zero. Adjust length of pushrods accordingly.

15. Final adjustments

15.1. Tail rotor adjustments

15.1.1.
Adjust tail rotor servo to neutral position.

15.1.2.
Length of pus rod cable must be such that the short shank of the bell-crank ot the tailrotor gear box is at right angles to the tailrotor transmission. See ill.

15.1.3.
Install tail rotor blades into blade holders, as shown by relevant illustrations of the airframe instructions ZELLE with M 3 x 13 screws and elastic stop nuts. Pay attention to proper direction of rotation of tail rotor. The curved upper side of the airfoil must face towards the fuselage.

15.1.4.
Tighten the blade holding screws firmly.

15.1.5.
Then loosen the blade holding screws.

15.1.6.
Now tighten the blade holding screws in such a manner that the tail rotor blades are lightly clamped in the blade holders and are still allowed to flap downward by gravity alone when the tail rotor hub is held horizontally.

Attention!

Centrifugal forces, acting on the tail rotor blades when the rotor shaft is spinning, overcome the blade droop and make the blades assume their optimum position which subjects the blade holder's ball bearings to the least load.

15.2. Main rotor head adjustments

15.2.1.
Move collective pitch/throttle control servo to neutral

15.2.2.
Attach servo pushrod to pitch control lever (23).

15.2.3.
See that pitch control lever (23) occupies center position in slotted pitch plate (22). If it does not, alter length of pushrod (210) joining bellcrank (105) and pitch control lever accordingly.

15.2.4.
Check level position of mixing lever (32) in see-saw hub (31). If not level, screw bearing block (17) in the intermediate bearing, (3) in or out, as required, and secure in new position with M 6 counter nut (16). Refer to exploded view 1.

If the helicopter is to be flown without collective pitch control, detach push rod (147) with keeper (148) from output arm of control servo.

Engage the push rod in the hole of attachment plate (217). Refer to illu-
rod (147) with keeper (148) from output arm of control servo.

Engage the push rod in the hole of attachmentplate (217). Refer to illustration on the plans ZELLE, No. 4600, on the right side of sectional view K - K.

Adjust length of threaded rod (210) connected to pitch lever in such a manner that each main rotor blade is set at +5° angle of incidence.

The next chapter describes angle of incidence adjustment of the main rotor blades. This step must be performed, regardless of whether the model is to be flown with or without constant blade pitch angle.

15.3. Main rotor blade pitch adjustment

15.3.1.
Adjust the servo which controls both the collective pitch and the engine throttle, to engine idling position. With this setting the rotor blades are adjusted to lowest pitch.

15.3.2.
Slip rotor blade pitch gauge onto tip of main rotor blade at right angles, with the inscription 1° and 5° on the left side, facing outward. On view-

ing along the rotor blade, the top edge of the gauge – marked 1° – must be parallel to the bar of the servo rotor held level, avoid negative pitch angles exceeding – 1°.

Helpful hint:

When adjusting each rotor blade preferably provide 1° of incidence at idle and be sure to check for proper blade tracking. Minor devialions from the specified angle of incidence settings are permissible and may, in some cases, yield and improvement.

15.3.3.

Move pitch control servo to maximum pitch angle setting now, which is identical with the full throttle position of the engine.

15.3.4.

When viewing along the rotor blade from the tip, the lower edge of the gauge – marked 5° – must be parallel to the bar of the servo rotor held level. Pitch angles exceeding 5° offer neither advantages nor do they improve the pitch effect. Maximum pitch angles kept below 5° may prove advantageous.

15.3.5.

Repeat the procedures described in 15.3.2. and 15.3.4. when adjusting the second main rotor blade.

15.3.6.

If both pitch angles of one of the blades, e.g. 1° and 5°, are found to be uniformly higher or lower than specified, this can be cured by altering the length of the pushrod connecting the mixing lever (32) and the blade pitch lever (35) by screwing the plastic ball link in or out, as the case may require, until both blades show the specified pitch angles.

Attention!

Be sure to follow the hints in the introductory remarks of the building instructions concerning ball links, how to connect and disconnect them and how deep the links must engage the plastic part of the ball link.

15.3.7.

If both rotor blades cannot be adjusted to the specified 1° and 5° pitch angles, (idle to full throttle) then the linkage (210) connecting bellcrank (105) and pitch control lever (23) must be reversed at the bellcrank.

15.3.8.

If the angle of incidence of the two rotor blades differs this means that one of the blade pitch levers (35) may be bent. Correct this by bending the blade pitch lever (35) towards the rotor head to obtain a higher pitch angle, bend it away from the rotor head to reduce the pitch angle. With the rotor head properly adjusted and the servo rotor blades (30) level, the push rods connecting the mixing levers (32) and the blade pitch levers (35) should be perfectly perpendicular viewed from all directions.

15.3.9.

Check static tracking of the rotor blades by measuring the distance between each main rotor blade and the rear end of the tail boom See fig.

Proper blade tracking is obtained by loosening and adjusting the damper „O" rings (46) accordingly, until the blade tips rotate in a common plane at a uniform distance from and above the tail boom.

The rotor head of the BELL 212 TWIN JET model helicopter permits adjustment of the see-saw movement of the rotor blades about a horizontal (flapping) exis. This enables the pilot to find the aptimum setting by trial and error.

For your first attempts **at hovering flight** the damper „O" rings (46) should be adjusted in such a manner that firm pressure is exerted against the main rotor hub (34) by the special rubber material of the „O" rigs. There should be no gap between the rubber and hub (34).

After extensive operation the rubber „O" rings may be deformed as a result of wear and tear. This is easily cured by turning the rings 1/4 turn, thereby moving fresh, un-deformed rubber into operative position.

16. Test running

16.1.

Place model helicopter on field box. Have a helper hold the model down.

Attention!

When running the model for the first time, be sure to always raise the rotor disk above head level. This is a precaution against accidents that may possibly result from thrown rotor parts that have been incorrectly mounted. The same precaution should be taken when test running the rotor after replacement of rotor head components.

16.2.

Fill tank, switch R/C gear on and check all servos for proper function. Then start engine, following the engine starting instructions supplied and using a V–belt and a suitable ecectric starter. Then insert V–belt into bracket of landing gear mount (176).

16.3.

Adjust engine and carburetor as per instructions, so that the engine idles reliably. With the engine idling the clutch must not yet engage. The idle setting of the motor is properly adjusted if the engine picks up reliably when throttle is opened after 5 minutes of idling.

16.4.

Adjust full throttle setting of engine next. Adjust needle valve setting for „rich" mixture, otherwise engine may overheat. Hold model firmly!

Under any circumstances the main rotor blades must not be held fast while full throttle is applied, otherwise the clutch will be destroyed.

Attention!

Should the helicopter start vibrating with increasing r.p.m., close throttle immediately to idle. Trace couse of vibrations.

They may result from:

16.4.1. unbalanced rotor,
16.4.2. rotor head not adjusted as per instructions,
16.4.3. power unit misaligned, loose screws,
16.4.4. unbalanced tail rotor.

16.5.

Check tracking of main rotor blades at high r.p.m. Thanks to the different coloring of the rotor blade tips the out - of - track tip can be easily identified. Reduce length of pushrod connected to blade pitch lever (35) of higher running rotor blade to reduce the blade angle.

Attention!

Be sure to keep in mind that hi - revving rotor blades represent a potential danger. During rotor checks your head will be near and on a level with the main rotor disk. For this reason it is recommended that you wear a head guard of robust small wire mesh in front of your face. A rotor blade flying off the hub could prove a deadly missile. Make sure that other persons do not come near the main rotor, in plane with the rotor disk!

Inspite of careful balancing of and the use of selected wood for the rotor blades their bending and torsional properties may differ when subjected to the high centrifugal forces induced by a fast spinning rotor. This elastic unsymmetry can be corrected by lengthening or shortening the linkage connecting the mixing lever (32) and the blade pitch lever (35), as the case may require. Be sure to keep adjusting until the two rotor blades are tracking correctly over the entire rotor speed range.

16.6.

Check all screws of the helicopter. They must be firmly tightened. This applies, in particular, to the clamping bolts of the large bevel gear (4), the rotor head, hub (34) of the main rotor, blade retention hub (42) of the tail rotor and the set screws of the couplings (11/12).

16.7.

Check center of grafity position of model. It must be coindident with the centerline of the main rotor shaft. If it is not, correct nose or tail heaviness by adding ballast at tail or nose of the fuselage, as the case may require.

16.8.

It is a good idea to take along a couple of matched sets of covered and balanced main rotor and tail rotor blades when travelling to the flying field. Remove one of the main rotor blades of the model by loosening the three mounting bolts at blade holder (26) for ease of transport.

16.9.

Recommended battery for the glo plug: The SONNENSCHEIN DRYFIT battery PC, 7.5 Ah, No. 3694. Use glo-clip equipped with leads of adequate length. See relevant hints in the engine operating instructions. Unscrew and check gloplug frequently. Also measure current now and then with a meter to check the state of charge of the battery.

17. Care and maintenance

17.1. General hints

17.1.1.

Check all bolts, screws and other hardware for firm seat and faultless condition ofter every 5 hours time of operation.

17.1.2.

Firmly tighten the screws at the clamping ring of the large bevel gear prior to each day's flying session.

17.1.3.

Use clean, filtered, and water - free fuel only. A nitromethane content of over 10% improves the running qualities of partly loaded engines.

17.1.4.
Use original ball bearings only. All ball bearings have been specifically tailored to the requirements of this model helicopter.

17.2. Lubrication

17.2.1.
Lubricate the tail rotor bearing between driven shaft and pitch operating rod with a **single** droplet of automobile oil (HP oil – SAE 20) after every 5 hours time of operation.

Lubricating spot 1

See Exploded view 1

17.2.2.
Lubricate the tail rotor flexible drive shaft (165) by a single droplet of oil (HP oil – SAE 20) at both ends of the stuffing box (161) after every 5 hours of operation.

Lubricating spots 2

Attention!

All other parts need no maintenance and must not be lubricated! This applies in particular to the teeth of the bevel pinion and the large bevel gear, which must not be lubricated or greased. This would only result in an undesirable accumulation of grit and sand in the lubricant, causing excessive wear.

Under no circumstances should the ball bearings be lubricated. They contain a special type of lubricant which provides safe operating times on the order of several hundred hours.

17.3. Cleaning

17.3.1.
Do not use cleaning fluids, such as gasoline, petroleum, thinner, trichlorethylene, carbon-tetrachloride, aerosols benzene, xylol, toluol stain remover etc.

17.3.2.
Wipe model and mechanical parts with paper handkerchiefs, such as Kleenex etc. only, or with clean linen cloth.

17.3.3.
Never wash mechanical parts with soapy or warm water!

18. Testflying

Be sure to remember the various, accident prevention measures mentioned before when operating the model – safety first!

Do not try to testfly the model until the preceeding bench tests have been performed as per instructions and have proved successful in every respect.

It is recommended that the trainer type of landing gear, No. 90, be used for initial tests.

Always select a hard, smooth and dustfree asphalt, concrete, bitumen etc. surface for your first test hops. Take-offs from grass present no difficulty for an experienced pilot, provided lift-off is executed quickly (jump take off) so that the helicopter does not flip over by getting caught in the grass.

The advantage offered by a hard surface used in conjunction with the training gear is that by sliding on the smooth surface, it gives the pilot advance information re. the direction in which the helicopter is going to move prior to the actual lift-off.

During initial test flights open the throttle slowly. With increasing revs the aft end of the helicopter will try to move either clock– or counter-clockwise. Observe the direction in which the helicopter wants to turn immediately before lift - off. This turning tendency must be compensated for by adjusting the tail rotor trim lever on the transmitter, before any attempt is made to fly the helicopter in the hover mode. Stop engine after these trim adjustments have been made. The pitch angle of the tail rotor blades determined in this manner must now be set by adjusting the length of the tail rotor push rod, so that the servo, as well as the trim lever and the stick at the transmitter can be returned to neutral position.

Proceed in the same manner, if the helicopter tries to move forward, backward or to the right or left prior to lift-off. Do not lift-off the model until all linkages habe been adjusted in such a manner that all transmitter sticks and trim units occupy their proper center positions. Full trim range must be available later for forward flight and other maneuvers, such as flights a round the field.

The most difficult phase of any flight is the landing! Prerequisite of a successful landing is a faultless hover flight at low altitude above the landing spot. It takes patience and lots of practice to learn how to hover a helicopter. And even if you are convinced that you fully master this phase of model helicopter flying, be sure to keep practising again and again!

Prior to touchdown the model must be made to hover over the landing spot. So be sure to practice hover flight until you get the hang of it. Permit the helicopter to slide in any direction, forward, backward, laterally. Then make it return to its original station and hover it directly over the landing spot.

When you are convinced that you fully master hovering flight, then try to perform spot landings from hover flight at a slow forward speed. Try again and again until the model lands right on the predetermined landing spot, flight after flight.

Attention!

Just like conventional fixed wing models, helicopters, too, must be launched and landed into the wind!

While circling the flying field, be sure to remember that lateral and directional controls must be properly coordinated, just as in the case of the fullsize craft, to make the centrifugal force, induced by turning flight, always pull in the direction of the rotor shaft.

During the landing approach the model must be made to descend relatively slowly and at a uniform rate of sink. Not only does the flare - out of a helicopter require lots of engine power, but, still worse, a helicopter descending too quickly may enter into a flight regime which makes flaring impossible, despite adequate power reserve. Moral: on executing the approach maneuver see to it that the model is not flying higher than 3 1/2' above the predetermined landing spot when it comes to rest, e.g. starts hovering, then set it down slowly.

Important notice

The duration of flight is limited by the amount of fuel carried by the model. Flying by stop watch is therefore a must, so you can check the elapsed flying time and be sure that ample fuel reserve will be avilable for a safe landing. The capacity of the tank provides about 15 minutes of flight time.

The chapter ,,mechanics of flight" informs you about the control functions required for the various maneuvers and about the aerodynamic forces involved.

19. The mechanics of flight of the helicopter

With the aerodynamics of, and the aerodynamic forces encountered by the helicopter differing somewhat from those of fixed wing aircraft a short introduction to the basic mechanics of flight of the helicopter should prove useful. Being familiar with the forces induced by the various maneuvers of a helicopter will facilitate its operation and reduce the danger of crash landings caused by pilot error.

The main disadvantage of fixed wing aircraft featuring fuselage and empenage is the loss of control encountered when flying too slowly. Another disadvantage of this type of flying machine, both fullsize and scaled-down model replicas, is their need of runways for take-offs and landings. The desire to create a flying machine capable of vertical ascent and descent, of flying slow or fast, of standing motionless in the air and hover, is an old one and, in fact, Leonardo da Vinci sketched his idea of a technical solution ot this problem as early as in the 16th century. But experimental types of vertically rising and landing aircraft were not built and successfully flown until the geginning of this century.

The basic idea for this type of aircraft consists in replacing the fixed wings of conventional airfraft by a system of rotating wings or rather by a horizontal airscrew, that is a lifting propeller. The first helicopter to fly successfully and with acceptable control characteristics were those built by H. Focke (1936), Flettner (1939) and Sikorsky (1941). All of them were to some extent based on the valuable data collected since 1926 by Juan de la Cierva with his experimental autogiro or gyroplane. This type of rotary wing aircraft differs from the helicopter in that its rotor is not driven by an engine, but by airforces resulting from the motion of the craft through the air. Forward propulsion is provided independently of the rotor, generally by a propeller, as in the manner of fixed wing aircraft.

While modellers succeeded in building and flying scalec-down au to giros quite early, the problems posed by the mechanically driven helicopter remained unsolved for a long time. As a result of many failures it was finally realized that the only answer would be a remotely controlled model helicopter, flown under constant control, hence quasi - stable and therefore airworthy. The possibility of flying a model at any arbitrarily selected low speed, of hovering, vertical take-off and landing, can only be provided by the remotely controlled model. Let's now take a short look at the mechanics of flight of the helicopter and the latter's peculiarities differing from those of fixed wing airfraft.

One of the major problems of helicopters with driven rotors is the compensation of the torque created by the engine driven rotor blades. While the torque effect of propeller driven fixed wing models or planes can be compensated rather simply by appropriate adjustments of ailerons and thrustline (sidethrust), the compensation of the torque affecting a helicopter requires special devices. To get around the torque problem of the helicopter with driven rotor a second, vertically mounted rotor is provided at the rear end of the fuselage; it is called tail rotor or anti - torque rotor. This tail rotor ideally provides just the right amount of side thrust to compensate for the torque acting on the main rotor, by employing the fuselage as a lever. To fill this requirement its thrust must be constantly adapted to prevailing conditions, in particular to any change of engine power applied to the main rotor. This is performed by changing the angle of pitch of the tail rotor blades accordingly. The tail rotor is therefore designed as a variable pitch propeller. It is generally a rather complicated part and, being mounted in an exposed position near the tail end of the fuselage, rather vulnerable in the case of rough landings.

19.1. Hovering flight

Fig 18 shows a helicopter in stationary flight, e.g. in the hover, schematically.

Much like the conventional propeller or airscrew, a helicopter's rotor provides thrust or rather up-thrust (or simply lift). The helicopter hovers stationary when lift and weight of the helicopter balance each other. Actually though the lift must exceed the weight slightly, because of the downwash of the rotor hitting fuselage, tailhoom, landing gear struts etc., thereby producing negative lift. The tail rotor provides torque compensation. Without such a device the fuselage would rotate in an opposite direction to that of the rotor.

19.2. Ground effect

Modellers know that a spinning propeller produces a blast of air which is felt when one sticks one's hand into the airstream. Just like a propeller the helicopter's rotor produces a blast of air too, which is directed downward. When a helicopter gets close to the ground, during landing for example, the downwash of the rotor is increasingly deflected outwards instead of downwards, thereby creating an air cushion on which the helicopter floats. This phenomenon is called ground effect. While skipping the mysteries of rotor aerodynamics let's mention the positive effect of this air cushion. Floating on the air bubble it permits a helicopter to lift more weight for a given engine power. This effect diminisches as a function of height above the ground and is restricted to a height equalling one rotor diameter above the ground. This is the explantion why an underpowered helicopter, though capable of lift off, will be unable to leave the ground effect zone.

19.3. Vertical climb

The transition from hovering to climbing flight requires additional power, e.g. the throttle must be opened by the pilot. Increased power means increased rotor lift: the helicopter climbs.
In the case of helicopters featuring rotor blades with f i x e d pitch higher lift is achieved by increasing the rotor speed. Response is somewhat s l o w with this method of increasing the lift of a model helicopter, because the combined masses of flywheel, gears and rotor must be accelerated by the engine before the faster spinning rotor produces more lift. In a helicopter with constant pitch rotor blades the rotor speed must be increased with any increase of the rate of climb in order to retain the angle of attack of the rotor blades.

However a helicopter featuring collective pitch reacts much faster when ordered to climb. And during the approach, flare - out is quickly achieved by adjusting the pitch of the rotor blades accordingly. As a rule the helicopter equipped with collective pitch control will be much more maneuverable than the constant pitch model, hence will be easier to fly. The kinetic energy built up in the rotor system by changing the blade pitch slightly without altering the power setting, enables the pilot to perform junp take-offs with his model, with the latter showing no tendency to swing to either side. If engine power is increased simultaneously and proportionally with the alteration of the pitch angle, the rotor speed will remain constant and there'll be no delay in response due to masses requiring acceleration.

Any increase of the engine power by opening the throttle and the resulting higher torque acting on the rotor do, of course, necessitate a corresponding adjustment of tail rotor thrust to retain the equilibrium of moments. The main advantage of collective pitch control is that the kinetic energy of the main rotor may be used to permit flaring the helicopter while landing or in a critical situation without a tendency for the model to rotate to the right or left and without the need for actuating directional control via tailrotor adjustment.

19.4. Vertical descent

A peculiar effect can be noticed during a fast vertical descent of the helicopter. When the sink rate of the helicopter almost equals the downwash velocity of the rotor, the latter enters into a critical flow condition called the vortex ring state. (See fig.)

In this state the rotor is unable to produce the required amount of lift because air from beneath flows against the rotor as a result of excessive rate of sink. The rotor is in fact setting in its own downwash. Instead of flowing downward through the rotor, the air passing through the rotor is deflected laterally and, recirculating through the blade tips, builds up the vortex ring.

The airflow about the outer blade setions is highly turbulent, resulting in separation of the boundary layer around the blade. The lift produced by the rotor diminishes rapidly and the helicopter crashes. This critical phase can be avoided by descending the helicopter in forward flight, because forward speed keeps providing the rotor with a non-turbulent inflow. For this reason fast descent must be coupled with forward flight; this also holds true with model helicopters. A helicopter may also encounter the dangerous vortex ring phenomenon when turning from upwind into downwind flight, as the wind then blows from underneath against the tilted rotor.

19.5. Level flight

A helicopter travelling at constant speed in level forward flight is subjected to the forces shown by diagram. 20.

Weight G is directed downward, as usual. Fuselage, rotor and landing gear create parasite drag W, which acts in an aft direction, when passing through the air. A rotor spinning in hovering flight creates lift which acts in the direction of and concentric with the rotor shaft. When the helicopter is in forward flight the direction of the lift force is no longer in line with the rotor shaft. The lifting force, here designated Pres, is now inclined ed in relation to the rotor axis. This is the result of dissymetry of rotor blade lift which occurs when a rotor is in forward flight. In a spinning rotor one of the blades moves forward, the opposite blade moves backwards. The advancing one produces more lift because forward speed and rotaitional speed add up to a higher total blade speed than in the case of the retreating blade, where the aircraft's speed must be subtracted from the rotor speed. The combination of rotational and forward velocities results in a dissymetry of lift between the two sides of a rotor disk. By splitting up the lift force into two components one obtains lift A, which should be equal to weight G, and forward thrust Z; the latter is, of course, the equivalent of the thrust of the conventional propeller. To point the forward thrust component Z in a forwardly direction or any desired direction of flight, one must tilt the rotor disk to the horizontal accordingly.

19.6. Rotor blade flapping

The advancing blade of a rotor tends to rise as a result of the higher lift it produces. This would cause toppling of the rotor axis if the rotor blades were rigidly attached to the rotor shaft. The main rotor shaft is prevented from tilting by the provision of flapping hinges which connect the rotor blades to the rotor shaft.

In the case of the BELL 212 TWIN JET helicopter model the two rotor blades are rigidly interconnected and hinged at the center by a common (teetering) hinge which is in turn fastened to the rotor shaft (see fig. 21). This type of rotor arrangement offers significant advantages both aerodynamically and with regard to vibration problems.

With the blades free to flap as a unit, one of the blades moves up, while the other one moves downward. On moving downwards the retreating rotor blade will fly at a higher angle of attack which produces a welcome increase of lift, although it moves backward in relation to the helicopter. Rotor flapping with this type of hinge is markedly reduced because of the rigid interconnection of the rotor blades and the centrally arranged common hinge, which also results in low vibrational excitation in the hover mode.

The BELL 212 TWIN JET helicopter model provides a means for reducing and partially limiting the seesaw motion of the rotor. These means consist of rubber ,,O'' rings acting as a damper. The damper is adjustable and permits altering the control characteristics of the helicopter. The rotor head of this model helicopter is designed in such a manner as to provide, via its control system, an automatic reduction of the pitch angle when the rotor blade flaps upward, thereby creating a restoring moment. That's the reason why the rotor of this helicopter model spins with surprising smoothness and without major flapping motion.

The oscillations of the rotor blades cause an alternate increase and decrease, respectively in distance of the centers of blade mass from the center of rotation (see fig. 22) and thereby produce a phenomenon called Coriolis acceleration. This effect is utilized by ice skaters to increase their rotational speed when performing a pirouette. Spreading his arms he gathers momentum and increases his rotational speed by pressing them against his body. Physically speaking this is an example of the conservation of energy.

The faster a helicopter flies forward the more will the resulting rotor force Pres be tilted in the direction of flight. The force acts on the rotor axis at a point positioned above the flapping hinge. This point is called neutral point because its distance from the flapping hinge varies very little

19.7. Helicopter in translational flight mode

Power requirements for a helicopter in level forward flight are lowest when it cruises at a speed corresponding to about 50% maximum speed. The excess power available can be converted to climbing flight. For this reason a helicopter climbs faster when travelling forward at low speed than when rising vertically and it will also climb to a higher ceiling in the translational flight mode. Thaks to its highly efficient mechanical components the BELL 212 TWIN JET has lots of excess power for high rates of climb, on the order of 17 ft. per sec. max.

19.8. Autorotation

In case the engine stops while the helicopter is flying at an altitude of some 3 – 6 ft. above the ground, the kninetic energy stored in the spinning rotor can be expended to ensure a safe landing. With the engine disengaged and adequate forward speed, obtained by reducing the pitch angle to minimum setting, the model can be safely landed from an altitude of 35 ft. or more with the rotor in autorotaion, auto gyro fashion. Form any altitude in between these two limits the model helicopter cannot be flared out - just like the fullsize craft. For this reason a reliably performing engine is a prerequisite for the crash-free operation of a model helicopter.

20. How the controls work

The following chapter explains in simple terms how the controls of the BELL 212 TWIN JET model helicopter work. Modellers will find this text helpful in understanding the basic principles of the machine and they'll realize how logical, optimized and practical the layout and shape of the various components actually are. In view of the optimization of the mechanical parts-and this applies to both complete subassemblies and individual parts-modifications cannot possibly improve them, rather they may spoil them. And here's how the controls of the BELL 212 TWIN JET model helicopter work.

When a helicopter is hovering the position of the center of gravity should be coincident with the centerline of the rotor shaft. In this phase the point of action of the lift of the rotor is also coincident with the center line of the rotor, as shown. In very rare cases this will actually be true, however, resulting in a more or less pronounced tendency of the helicopter to topple. Its instability can only be compensated by corresponding actuation of the controls by the pilot so that the resultant of the lift forces and the c.g. are made to coincide properly.

When a helicopter is subjected to a gust of wind and, as a result, floats slowly to one side or the other, the direction of the lift forces travel in the direction of flight, as shown, and are no longer coincident with the center of gravity.

The controls of the helicopter now tilt the resulting lift or thrust of the rotor about the neutral point. In the case of the BELL 212 TWIN JET model helicopter cyclic pitch control has been provided for this purpose. This is a control mechanism for periodically varying the blade angle of each blade in its cycle of rotation. Pitch is increased during one half of a rotor shaft turn and decreased in the ensuing half turn, cousing the blades to rock, providing a diametrically opposite and simultaneous change of blade angle. The plane of rotation tilts and in the process the resultant lift force is also tilted about the neutral point and coincides with the center of gravity once the proper angle of tilt has been obtained.

The periodical variation of the blade angles is achieved by a swashplate, the tilting of which is actuated via remote control. The two main rotor blades are not directly coupled to the swashplate, rather the two servo rotor blades are. When the swashplate is tilted the plane of rotation of the servo rotor blades is also tilted. The blade angle of these auxiliary blades is also tilted. The blade angle of these auxiliary blades is now changed periodically until the angle of tilt of the swashplate is properly duplicated by that of the servo rotor blades. The servo rotor blades are connected to the main rotor blades via a system of levers and thereby control the pitch angle of the main rotor blades. This type of pitch control is used by various types of Bell and Hiller helicopters. Servo rotors act as a gyro when heavy; they also serve as aerodynamic amplifiers and vibration dampers. Aerodynamic amplification is mandatory in order to prevent excess loading of the R/C control servos. Aerodynamic damping is highly desirable in that it dampens the response of the helicopter model to control signals and disturbing forces such as gusts of wind.

By optimisation of rotor blade weight, proper design of the servo rotor. correctly matched linkage dimensions a model helicopter featuring excellent attitude holding qualities has been created. Despite its stability the model reacts instantly and readily to control signals.

Page shows an exploded view of the rotor head. The rotor shaft (8) is rigidly connected to main rotor hub (34). The forward facing tenon (54) forms the flapping axle for the two bridge plates (37) which carry the blade holders (36) and in which the two main rotor blades are mounted in special ball bearings and needle bearings. Cut outs in the two bridge plates permit passage of the blade pitch levers (35). Pushrods are connected to the ends of these levers (35). The free ends of the latter are linked to the mixing levers (32) which pivot about pin(33) of the seesaw hub (31). The tenons of the collective pitch yoke (27) engage the slots of parts (32). The collective pitch yoke (27) is axially positioned on the pitch control rod (20), which slides in rotor shaft (8). The servo rotor blades (30) are mounted on servo rotor shaft (29), mounted in the seesaw hub. The pitch angle of the servo rotor blades is cyclically varied by the swashplate via a pushrod connected to the pitch control horn (28). The seesaw hub is in turn pivotally mounted in the main rotor hub (34), using bolts (54) for a pivot.

Lets take a look at the control sequence (arresting the collective pitch rod for a moment to simplify matters): an R/C signal tilts the swashplate (24) towards the plane of rotation. This results in a cyclical variation of the pitch angle of the servo rotor blades (30). The plane of rotation of the latter is now tilted accordingly and so is the seesaw hub (31). Via mixing levers (32) and push rods connected to the blade pitch lever (35) the pitch angle of the main rotor blades is periodically varied.

This causes the main rotor to move toward a new plane of rotation, until the tilt of the swashplate coincides with that of the rotor planes of the servo rotor and the main rotor.

When the pitch control rod (20) is now shifted axially within the rotor shaft the pitch yoke (27) tilts the mixing levers (32) and varies the pitch angle of the main rotor blades collectively, e.g. in unison, via pushrods and levers (35).

The type of control mechanism provided for this model allows the use of cyclic and collective pitch control either independently or simultaneously.

A tail rotor is provided for main rotor torque compensation. It is also used to provide directional control by altering the pitch angle of the tail rotor blades. In order to simplify the control system and its operation, the collective pitch control system for the main rotor has been coupled to the throttle lever of the engine carburetor: full throttle is coupled to maximum pitch angle, idle is coupled to minimum pitch.

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Subject to changes serving technical progress.

21. List of materials MECHANIK – BELL 212 TWIN JET

This list of materials lists all parts again which are designated by a part number in the instructions, list of spare parts and exploded views.

Attention!

The list of materials does not list all parts of the various assembly groups for clarity.

Part No.	Designation	Amt. req.	Material	Dimensions in mm
1	socket head screw	1	steel	M 3 x 8
2	idler bearing shaft	1	steel	comm.item
3	intermediate bearing	1	plastic	comm.item
4	large bevel gear	1	plastic	comm.item
5	aluminum tube	1	aluminum	comm.item
6	bearing plate	1	aluminum	comm.item
7	bearing plate	1	aluminum	comm.item
8	main rotor shaft	1	steel	comm.item
9	bearing	1	plastic/ steel	comm.item
10	top rotor shaft bearing	1	plastic/ steel	comm.item
11	drive shaft coupling front	1	aluminum	comm.item
12	drive shaft coupling rear	1	aluminum	comm.item
13	bevel pinion	1	steel	comm.item
14	screw	1	steel	M 4 x 20
15	counter nut	1	steel	M 4
16	counter nut	1	steel	M 6
17	bearing block	1	aluminum	comm.item
18	bearing bolt	1	steel	comm.item
19	spring washer	1	steel	comm.item
20	pitch control rod	1	steel	comm.item
21	bushing	1	brass	comm.item
22	slotted pitch plate	1	plastic	comm.item
23	pitch control lever	1	aluminum	comm.item
24	swash plate	1	aluminum/ steel	comm.item
25	drag link	1	plastic	comm.item
26	blade holder	2	plastic	comm.item
27	collective pitch yoke	1	plastic	comm.item
28	pitch control horn	1	steel	comm.item
29	servo rotor shaft	1	steel	comm.item
30	servo rotor blade and rod	2	plastic/ steel	comm.item
31	seesaw hub	1	plastic	comm.item
32	mixing lever	2	steel	comm.item

Part No.	Designation	Amt. req.	Material	Dimensions in mm
33	shoulder screw	2	steel	comm.item
34	main rotor hub	1	plastic	comm.item
35	blade pitch lever	2	steel	comm.item
36	blade holder	2	aluminum	comm.item
37	bridge plate	2	aluminum	comm.item
38	bell housing	1	aluminum	comm.item
39	clutch shoe	2	plastic	comm.item
40	flywheel nut	1	steel	comm.item
41	tail rotor transmission	1	steel	comm.item
42	tail rotor hub	1	brass	comm.item
43	pitch control bridge	1	plastic	comm.item
44	tail rotor collar	2	steel	comm.item
45	servo rotor collar	3	steel	comm.item
46	damper „O" ring complete	2	– –	comm.item
47	main rotor blade bolt mounting	2	steel	comm.item

21.1. The MECHANIK kit contains the following ready - to - install assembly groups

1 ready-to-install power unit, including HB 61 STAMO glo engine with radial cooling fan and special muffler No. 1546, special flywheel, automatic centrifugal type clutch and main rotor gear box.

1 ready-to-install main rotor head with collective pitch control

2 servo rotor blades

1 ready-to-install main rotor shaft, complete with bearing, swashplate and pitch control rod

1 ready-to-install tail rotor gear box

The kit also contains:

1 main rotor blade pitch setting gauge

1 pitch lever (23)

The MECHANIK kit contains several plastic bags with miscellaneous parts; the bags are coded by capital letters A, B, C, D and E.

These bags contain the parts required for a specific assembly group or groups.

The following compilation lists the contents of the various bags and the purpose of the parts contained in them.

21.2. Table of contents of plastic bags

Bag	application	Part No.	Contents	Amt.	Remarks
A	carburetor	—	needle valve extension	1	
		—	open-end wrench SW 5.5—SW 6 mm	1	
	assembly work	—	Allen wrench SW 1.5 mm	1	
		—	Allen wrench SW 2.5 mm	1	
	for pre-drilling holes for blind nuts (pronged nuts) used to mount the power unit	—	ultra-long drill bit 13/64 Ø x 5 1/8"	1	
	for balancing the tail rotor blades	—	balance clip	2	
B	guide for pitch control lever	22	slotted pitch plate	1	The two bolts M 2.6 x 10, ex No. 705/10, and the two pronged blind nuts M 2.6 ex No. 728/26, used for fastening the slotted pitch plate (22), as well as the M 4 blind nuts M 3, ex No. 728/3, for fastening the main rotor bearing (10) are contained in the ZELLE kit No. 4600
	for fastening the top main rotor bearing (10)	—	socket-head screw M 3 x 8	4	
C	for attaching the power-unit to the longitudinal formers	—	cylinder head bolt M 4 x 20	10	The 10 blind nuts M 4, No. 728/4, are contained in the airframe kit ZELLE No. 4600
		—	lock washer J 4.3		
D	for fastening the tail rotor gear box to the fin	—	sheet metal screw cylinder head bolt A 2.2 x 13	4	
		—	washer, 9/320 d, 3/32 ID x 1/32	4	
E No. 88	order spare parts	—	socket head set screw M 3 x 3	3	
		—	lock nut M 3	3	STOP nut M3 1 nut for ball pin of swashplate abutment
		—	spring washer J 3.2.	3	
		—	ball link	2	
		—	engine bolt	3	
		—	muffler mounting bolt	1	
		—	threaded pin for carburator	1	
		—	socket head screw M 3 x 18	3	
		—	socket head screw M 3 x 25	2	
		—	socket head screw M 3 x 30	1	
		—	socket head screw M 3 x 8	2	
		—	lock washer for M 3.5	2	
		—	cylinder head bolt M 3.5 x 12	2	

22. Assembly group replacement parts of the MECHANIK kit

Order No.	Amt req'd	Designation
81	1	rotor head, **fully** assembled
81/2	1	blade holder, **fully** assembled (35), (36), etc.
81/2	2	damper „O" ring, with mounting hardware (46)
81/3	1	complete set of main rotor rods (27), (32), (33) etc.
81/4	1	plastic rotor blade holders with shaft installed
84	pair	servo rotor blades
85	1	main rotor shaft
85/1	1	top main rotor bearing, with mounting hardware (10)
85/2	1	swashplate, complete, with drag link (24), (25)
85/3	1	pitch control set, complete (20), (21), (23) etc.
85/4	1	rod set

Order No.	Amt req'd	Designation
85/21	1	swashplate engaging lever, **complete** (25)
86/1	1	tail rotor transmission, **fully** assembled (41)
86/2	1	tail rotor head, **fully** assembled with pitch control (42), (43) (44) etc.
86/3	2	tail rotor drive shaft couplings with set screws (11), (12)
86/21	1	pitch control bridge (43)
87/1	1	engine with flywheel
87/2	1	clutch, **complete** (38), (39)
87/3	1	intermediate bearing, **complete** (3)
87/31	1	idler bearing, with mounting bolt (2)
87/32	1	pitch bearing block, **complete** (18), (19), (20), (nut).
87/4	1	lower main rotor bearing, **complete** (9)
87/5	1	V-belt 1/4 x 17 3/4"
87/21	1	swashplate drag link **complete** (25)