Luftwaffe Self Synchronising Gyrocompasses - Patin Kurszentrales

The Patin “Kurszentrales” self synchronising gyro-compasses

Introduction

As aircraft design progressed towards faster and more advanced designs, one effect was that the frontal area of the aircraft was reduced. As a result, the width of the cockpits tended to be restricted with crew positions arranged behind eachother. At the same time the avionics systems grew more complex putting space for instruments and controls in the cockpit area at a premium.

As described in the chapter on the various autopilots, the autopilots required a cluster of three instruments (the PFK/f3 “Führertochterkompaβ”, the LKU 4 “Kurskreisel” and the LKZ 3 “Kurszeiger”) to provide a stable setpoint. Apart from the space requirements on the instrument panels, the sysnchronisation of the “Kurskreisel” required pilot intervention.

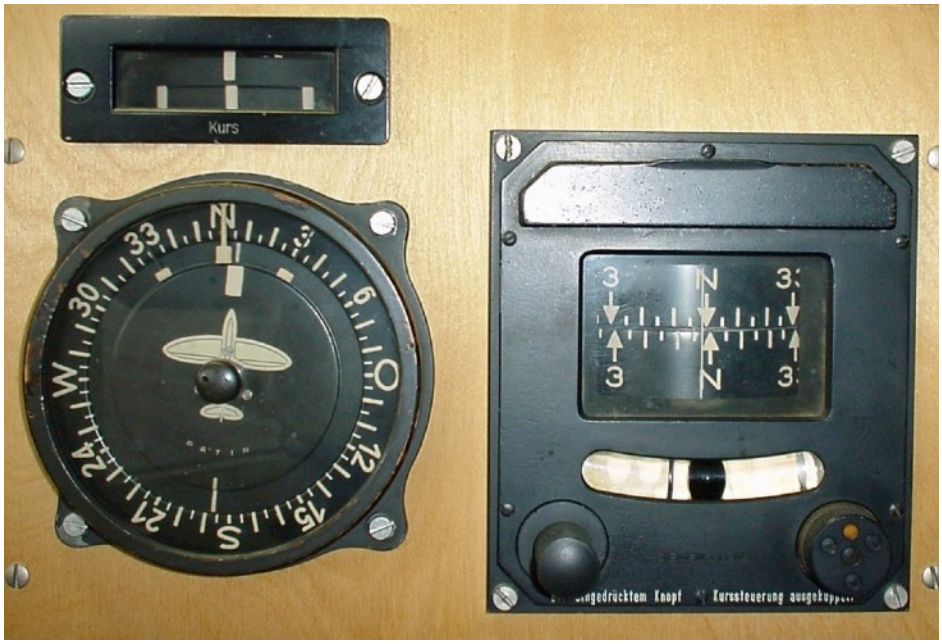

Figure 1: The standard instrument cluster required for an autopilot

This was the background against which Patin started development of a self-synchronising gyrocompass called the “Kurszentrale”. As with the “Kurskreisel”, the “Kurszentrale” was coupled to the standard Patin remote compass system and it had to provide a stabilised output signal for use with existing autopilots. The unit could be placed anywhere in the aircraft and remote operator intervention had to be kept as simple as possible.

Several repeaters can be connected to the “Kurskreisel”, for example a PFK/ f4 for the pilot and a PFA/R “Funkpeiltochter” for the navigator. These instruments would now receive a stabilised heading without showing the swings of the magnetic “Mutterkompaβ”.

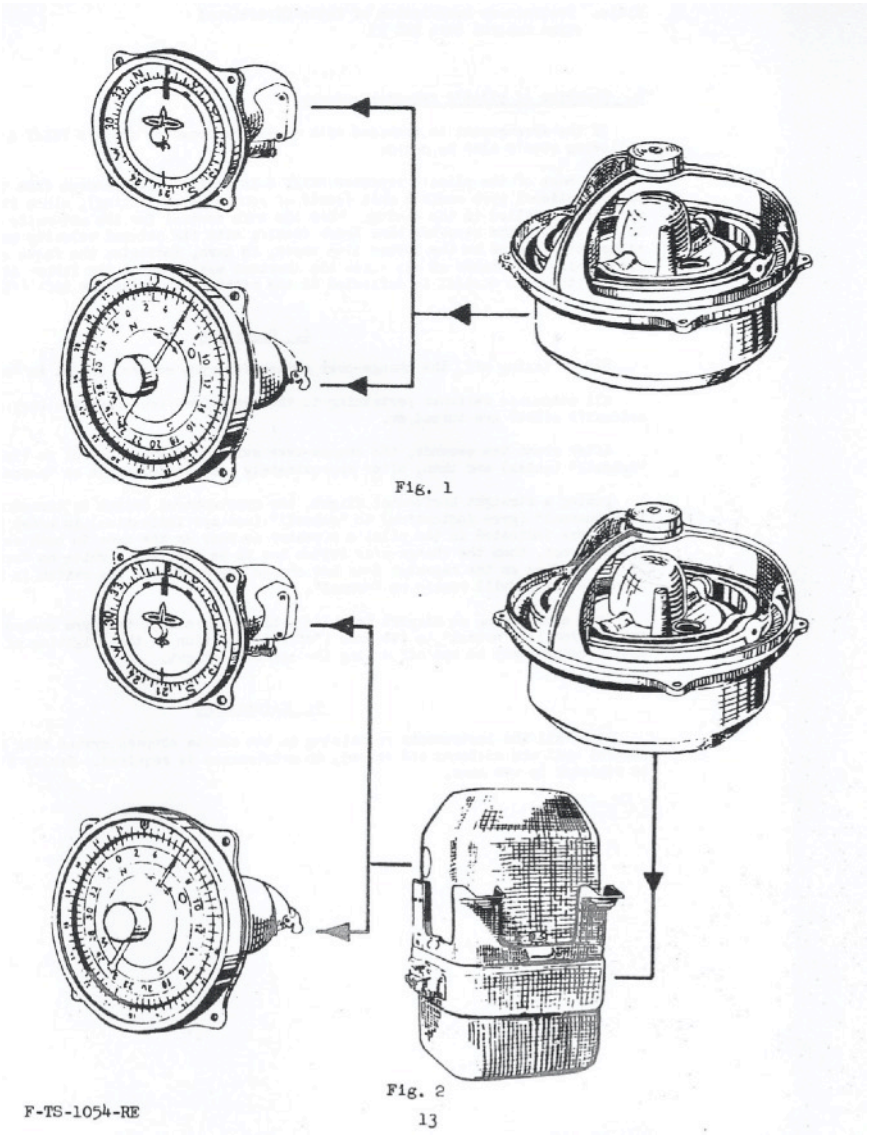

Figure 2: Diagram showing how the "Kurszentrale" is switched between the "Mutterkompaβ" and the indication instruments.

The first version was the Patin PKZ 13 “Kurszentrale” became available around 1940 in fairly limited numbers. This type was used in some marks of the Ju 88, Do 17 and He 111 in conjunction with the PDS “Dreirudersteuerung” and PKS11 “Kurssteuerung”. An improved and simplified design, the PKZ 14 became available around 1942 and was produced in large numbers. It was used in the AR 234, Do 335, He 218, Ju188, Ju 288, Ju 388.

Figure 3: PKZ 13 (Left) and PKZ 14 (Right) "Kurszentrales"

As the aircraft got quicker, so did the roll angles required for flying curves. High roll angles introduce an error in the indication of a gyroscopic compass requiring the gyrocompass to be mounted on a stabilised platform. In 1944, Patin started testing such a device named the PKZ 16. This complex system however proved difficult to manufacture and production was stopped before it could become operational.

Description of the Patin “Kurszentrale”

The complete Patin Kurszentrale required the following components:

- A PMK “Mutterkompaβ” master compass
- A PKZ 13, later PKZ 14 “Kurszentrale”
- A PSH 11, later PSH 17 “Kreiselüberwachungsschalter” control switch
- A PFK/f4, later PFK/f2 “Führertochterkompaβ” compass indicator
- A GDU “Drehstromumformer” generator (shared with the autopilot)

The PKZ 13 “Kurszentrale”is a 35 cm high unit, with a “Kursmotor” mounted to the side of the unit. Two plug sockets for the electrical connections are situated on the same side as the Kursmotor. A transparent window in the top cover shows a 360 degree scale.

Figure 4: PKZ 13 "Kurszentrale". Note the "Kursmoter" mounted at the side

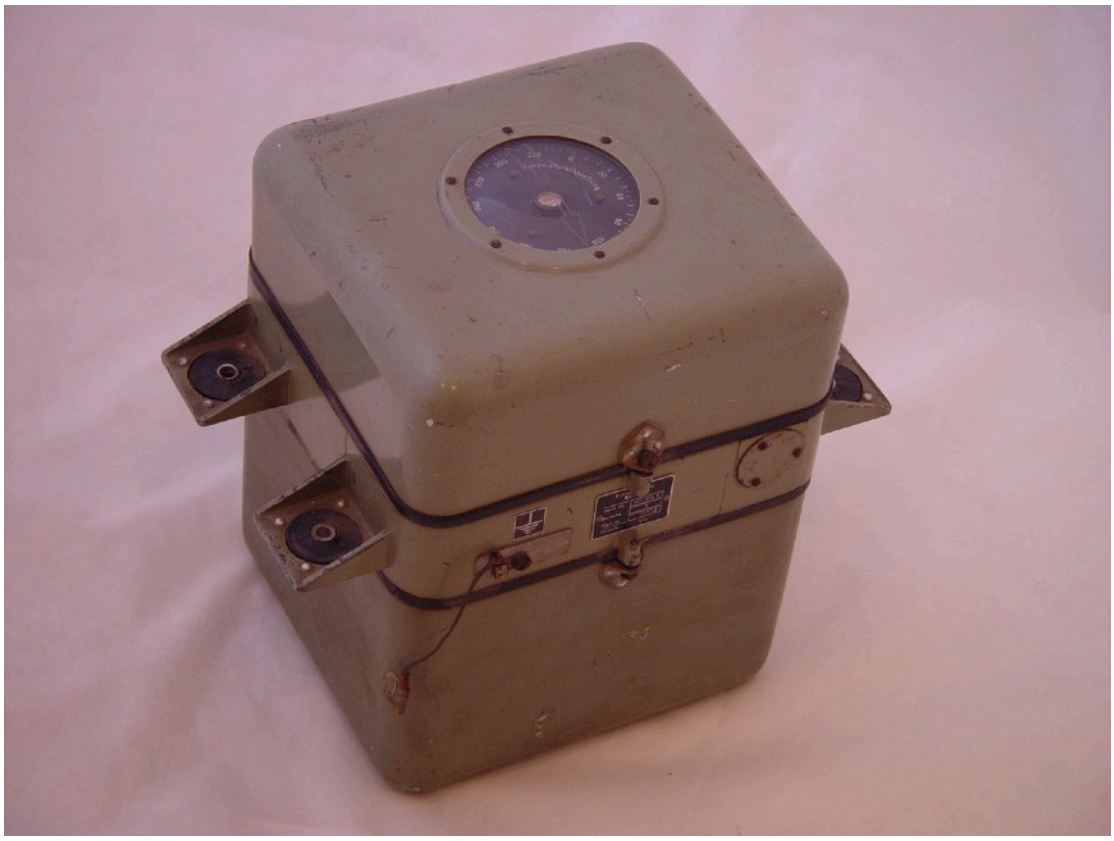

Figure 5: PKZ 14 "Kurszentrale". The Kursmotor is now mounted inside the housing

The PKZ 14 “Kurszentrale” has similar dimensions except the height was reduced to 26 cm. The “Kursmotor” has now moved to the inside, giving the unit a neater overall appearance. Again, two plug sockets provide the electrical connections and a transparent window on the top cover shows a 360 degree scale.

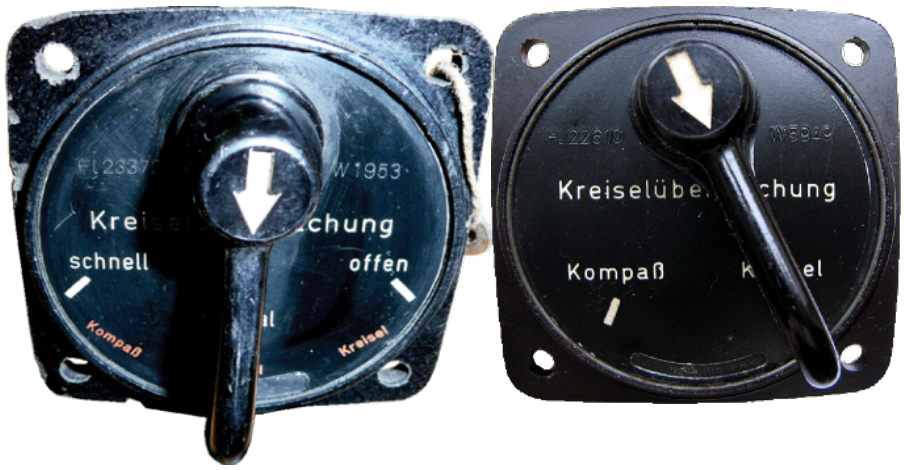

Figure 6: Left the PSH 11 "Kreiselueberwachungsschalter for the PKZ 13; rigth the PSH 17 for the PKZ 14

The “Kreiselüberwachungsschalter” regulates the operation mode of the “Kurszentrale”. The PKZ 13 had three operational modes, which was reduced to two with the PKZ 14. Both switches show the modes “Kompaβ” versus “Kreisel” while the earlier PSH 11 three position switch shows the additional markings “offen”, “normal” and “schnell”.

The patin PFK/f3 “Führertochterkompaβ” with the output resistor is no longer required. Initially a special PFK/f4 version of the “Führertochterkompaβ” with a motor drive was developed for use with the “Kurszentrale”. In later applications the smaller PFK/f2 version would be typical, offering maximum space saving on the instrument panel. With the PFK/f2 “Fühertochterkompaβ” the pilot was required to manually adjust the set course to the 12 o’clock position.

Figure 7: The PFK/f4 "Führertochterkompaβ" with motor drive for the outer indication ring

Figure 8: PFK/f2 small diameter repeater compass. Note the knurled bevel for manual setpoint adjustment

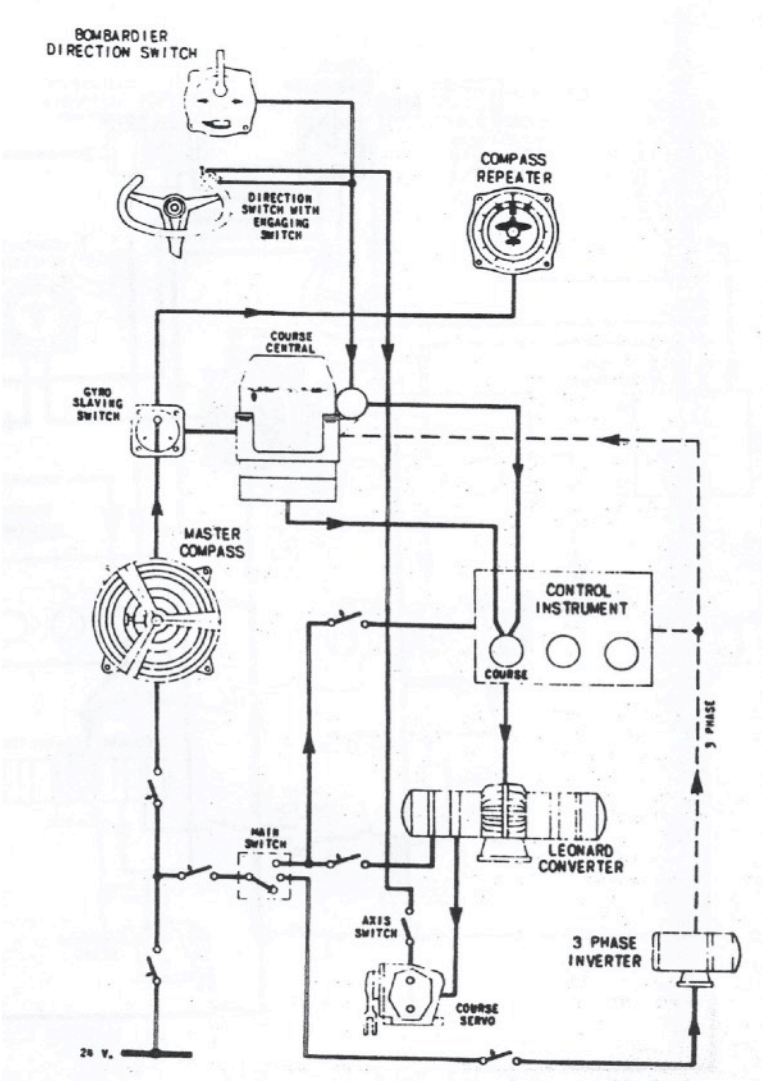

Figure 9: Diagram showing the PKZ 13 "Kurszentrale" coupled to the Patin PKS-11 autopilot

The Functioning of the Patin “Kurszentrale”

The principles of the Kurszentrale

The “Kurszentrale” has to perform a number of functions:

1. Receive the magnetic compass heading
2. Transmit a stabilised gyroscopic heading
3. Synchronise the gyroscope heading with the compass heading
4. Orientate the gyroscope axis horizontally
5. Set the heading set-point
6. Provide a signal to the autopilot of the deviation from the set-point

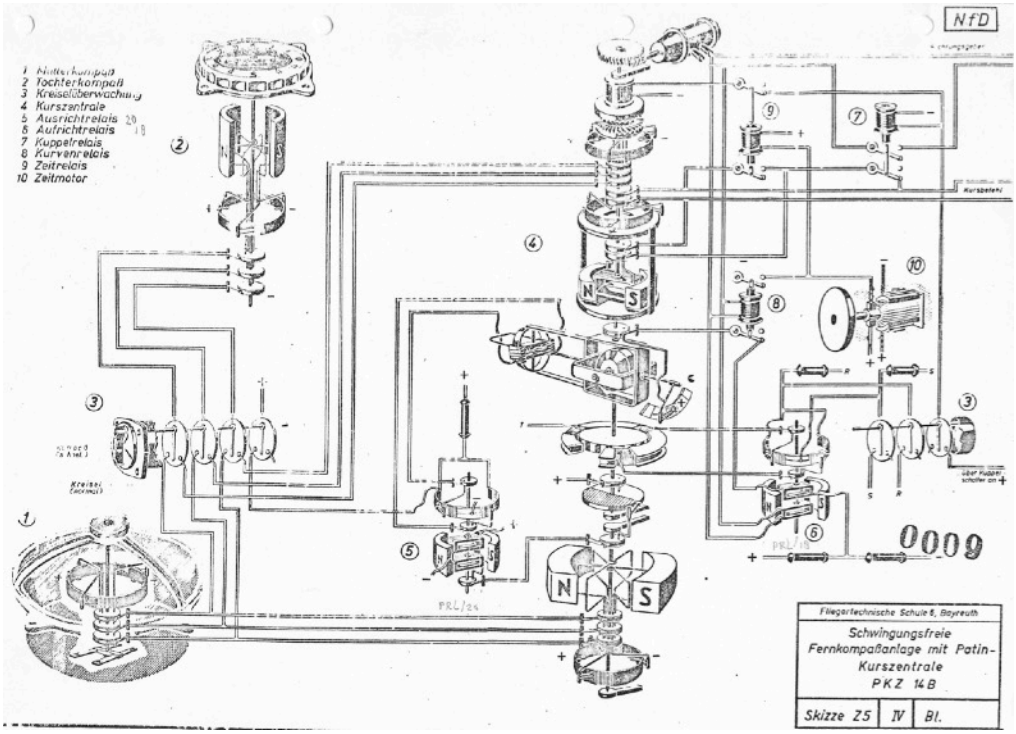

Figure 10: Schematic overview of the PKZ 14 "Kurszentrale" and peripheral equipment

The core of the “Kurszentrale” is a cardanically mounted gyroscope. With the axis of the gyroscope in horizontal position, the gyroscope will keep its course orientation stable when the aircraft is turning.

The “Kurszentrrale” contains a Patin compass receiver, essentially the interior of a PFK instrument minus housing and the compass rose. A contact disk is fixed to the axis of the compass receiver, while a small electrical runner contact connects to the axis of the gyroscope mounting frame. The contact disk conducts over half its circumference giving an indication of the relative position of the gyroscope mounting frame and the compass receiver.

The signal from the contact disk is send to a relay that drives two alignment coils on the mounting frame of the gyroscope. The way that a gyroscope reacts to a torque applied perpendicular to its rotational axis is to rotate

around its the other perpendicular axis (assume that the gyroscope rotates around the x-axis; applying torque to the y-axis will turn the gyroscope around the z-axis). So the torque generated by the alignment coils will rotate the gyroscope around the vertical axis. Once the gyroscope is aligned with the compass repeater, the torque will reverse and will keep oscillation around the alignment point.

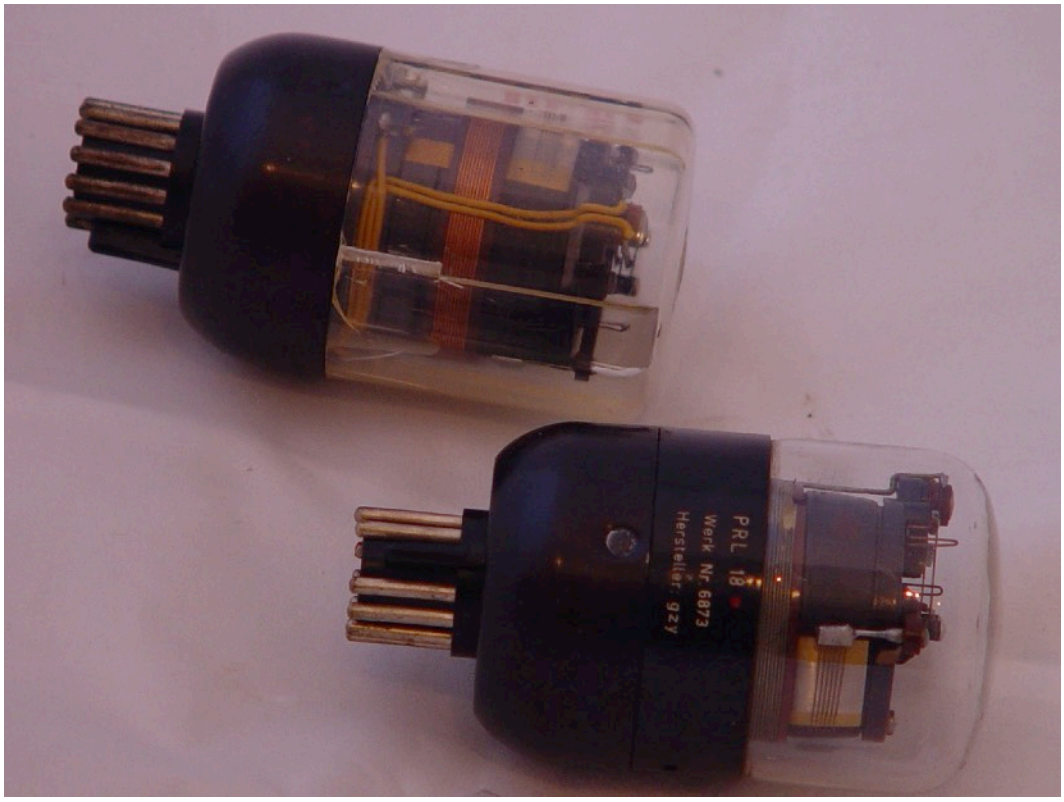

Figure 11: Two types of Patin PRL relays used in the "Kurszentrales"

To keep the axis of the gyroscope in a horizontal position, a similar method is employed. In the PKZ 13 “Kurszentrale”, a pair of contact disks connected to moveable weights on the cardanic frame give an indication of the horizontal orientation of the gyroscope. On the PKZ 14 this has been simplified to a single contact plate mounted directly to the cardanic frame. The runners are connected gyroscope housing. The signals from these contacts are fed to another set of relays. In this case the relays control a three phase asynchronous motor drive mounted in the base of the “Kurszentrale” which provides a torque around the vertical axis. The gyroscope reacts to this torque by changing its horizontal axis.

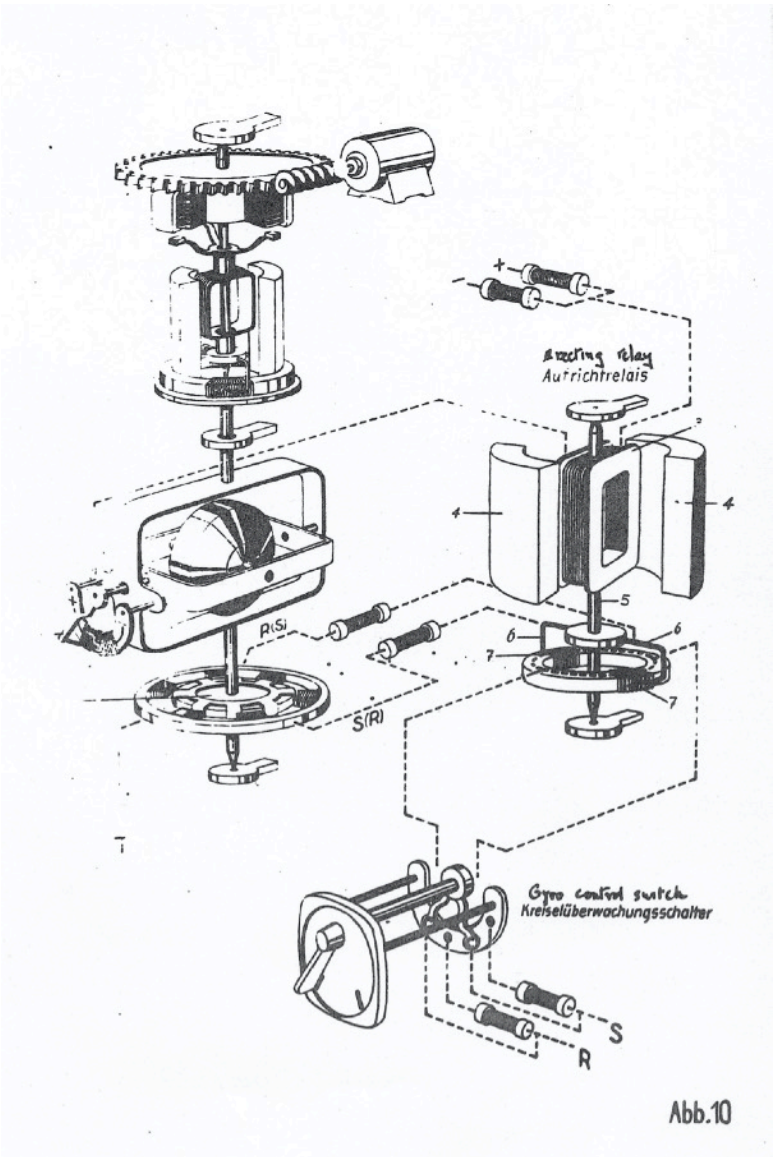

Figure 12: Schematic explaining the functioning of the orientation control in the PKZ 14 "Kurszentrale"

A Patin compass transmitter is connected to the mounting frame of the gyroscope so that the course position of the gyroscope can be transmitted.

The gyroscope mounting frame is also connected to a set of output potentiometers via an electromechanical clutch. If the clutch is disengaged, the output potentiometers are held in the central position so that the output signal to the autopilot is zero. With the clutch engaged, the output potentiometers are moved by the movement of the housing relative to the fixed position of the gyroscope.

With the clutch engaged, the relative position of the output potentiometers can be adjusted with the "Kursmotor" so that the set-point can be changed with the autopilot engaged. As usual, the "Kursmotor" is operated with the

“Richtungsgeber” mounted on the control column of the pilot, so that the aircraft can be turned by engaging the “Richtungsgeber”.

Both the synchronisation and the orientation of the gyroscope can be varied in strength. If the “Kreiselüberwachungsschalter” is switched to “Kompaβ”, a fast correction will take place (orientation 2-3 degree per second, synchronisation 1-2 degree per second) while in the “Kreisel” position the correction will be reduced to about 2 and 1 degree per minute respectively. In the PKZ 13, the synchronisation can be switched off completely if the “Kreiselüberwachungsschalter” is moved to the “offen” position.

This means that when the “Kreiselüberwachungsschalter” is placed in the “Kreisel/normal” position, the “Kurskreisel” will average the swinging motion of the magnetic compass in the same way as the “Kurskreisel”. This stabilised signal is displayed directly on the “FührertochterkompaB” and other connected repeaters.

The PKZ 13 “Kurszentrale”

In the PKZ 13 “Kurszentrale, the compass repeater, gyroscope and clutch and output potentiometer mechanism have all been placed in line over each other. The chassis of the “Kurszentrrale” splits the unit into two compartments, with the compass repeater and the control relays in the bottom half and the gyroscope and clutch mechanism placed in the top compartment. It almost seems like the fitting of the “Kursmotor” was an afterthought, with it being mounted on a bracket on the side of the unit.

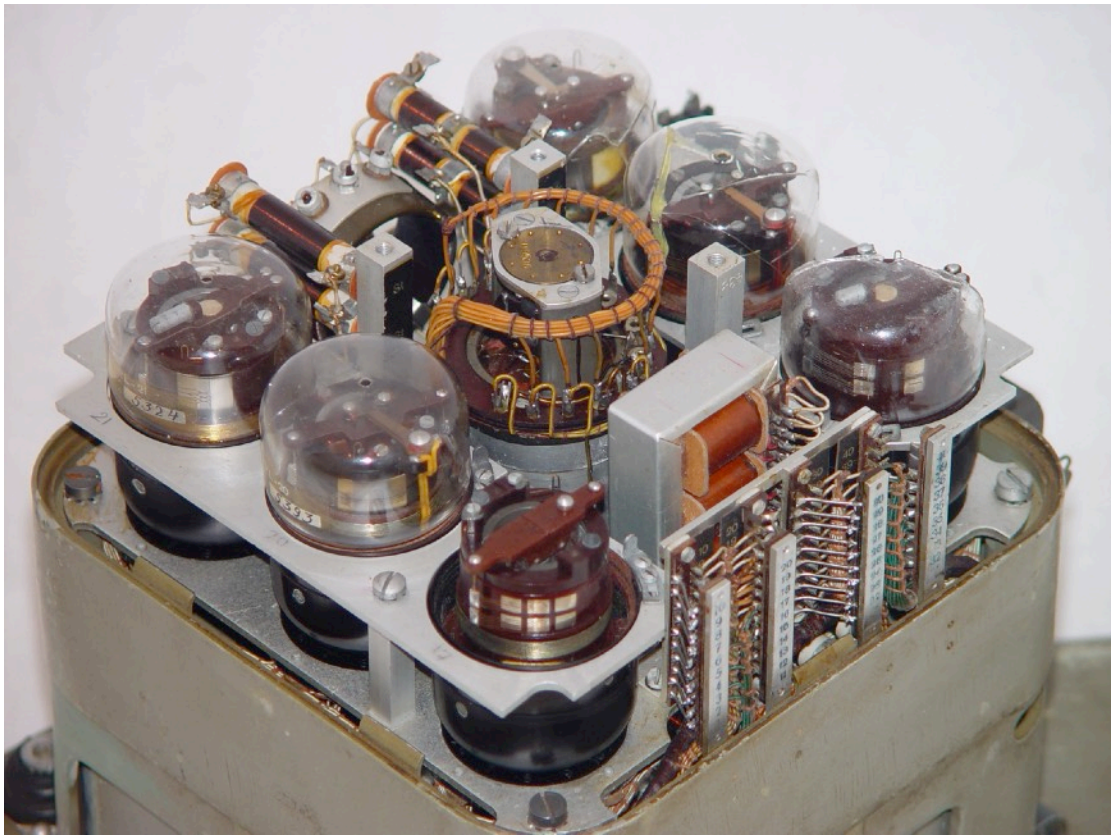

Figure 13: Bottom section of the PKZ 13 "Kurszentrale" with the cover removed. In the centre is the Patin compass repeater. Six PRL relays are placed around it on a "logic board".

A number of brushes provide electrical connections between the frame and the rotating parts of the “Kurszentrale”, most of these are mounted between the compass repeater and the frame.

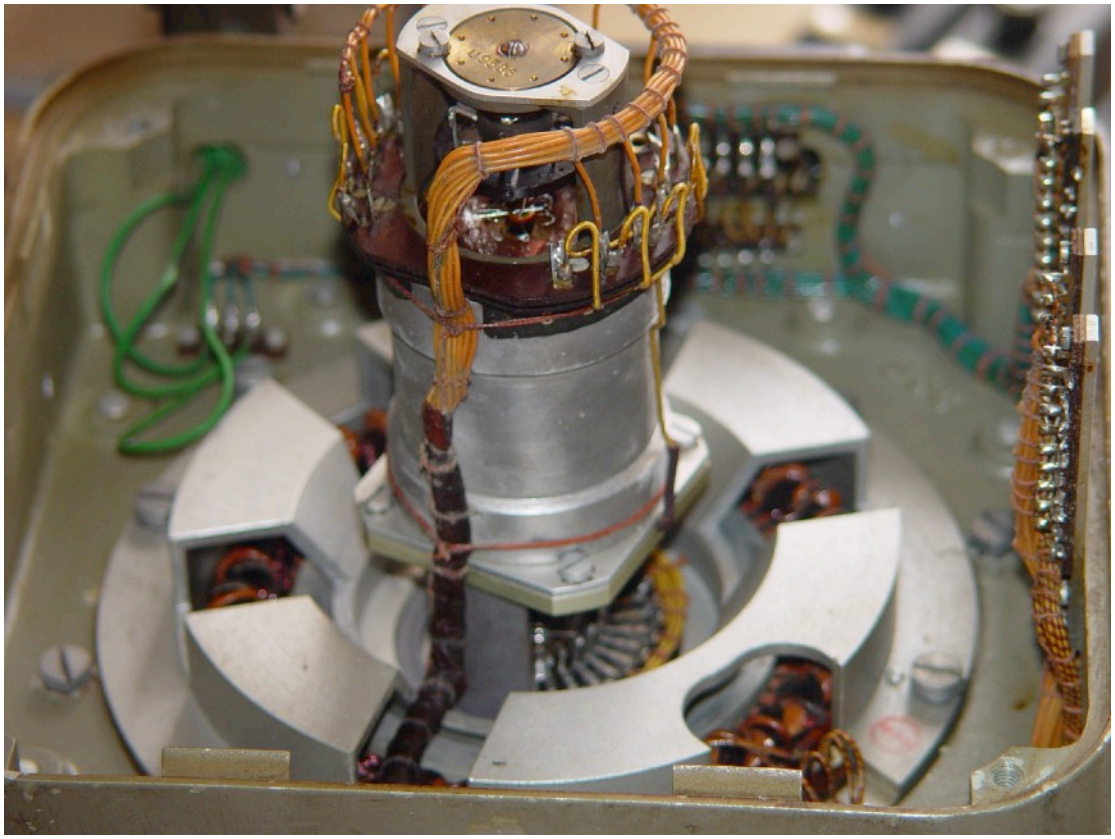

Figure 14: Bottom section with "logic board" removed showing the Patin compass repeater. Under this, are a number of brushes to transfer the electrical signals to the rotating parts. Note the windings of the asynchronous orientation drive around the base.

The synchronisation and orientation of the PKZ 13 gyroscope is regulated by six special relays. The relays are constructed in the typical Patin fashion like a galvanometer instrument. Each relay has several windings on a rotor around a magnetic core. The rotor connects to a set of runners providing a positive or negative output voltage. The runners either run on a potentiometer winding or on contact sections, dependent on the type of relay. All six relays are a different type, coded from PRL16 to PRL21.

The six relays plug into a “logic board”, which can be easily de-soldered and removed from the unit. The back of the control board contains a number of resistors that regulate the strengths of the various signals going to the individual windings in the relays.

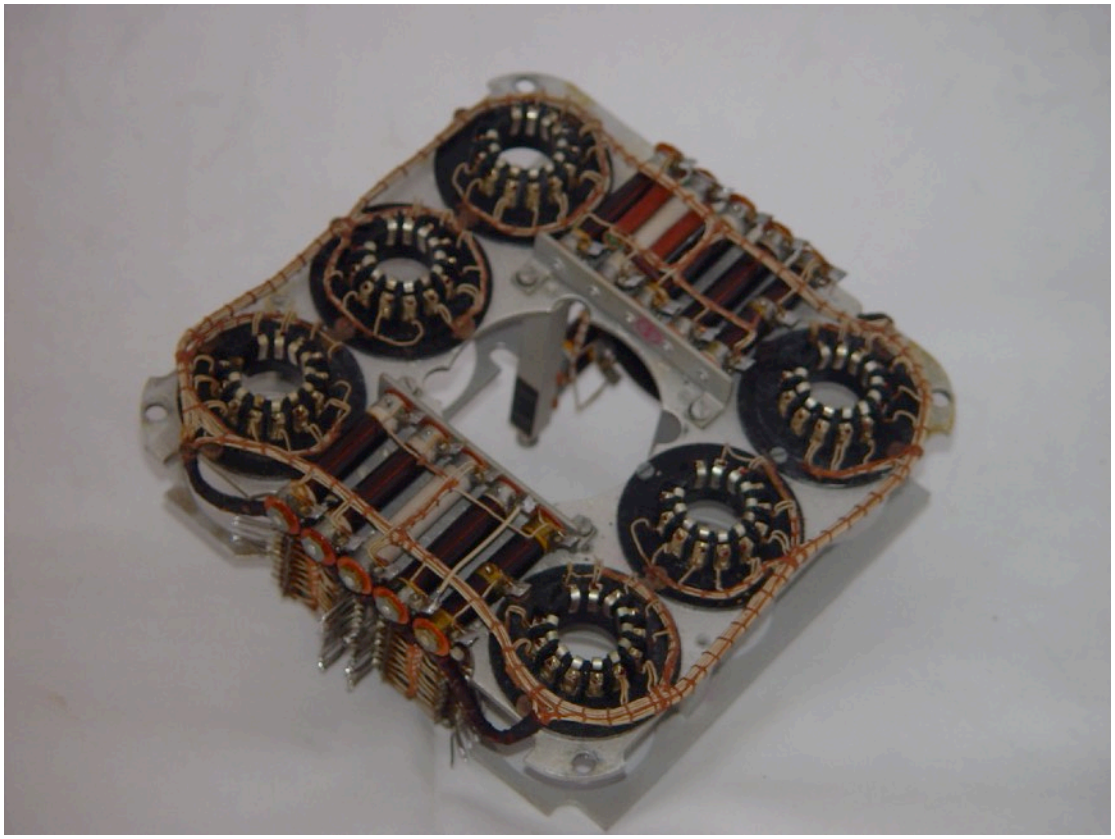

Figure 15: reverse of the "logic board" containing the PRL relays.

The PRL18 and 19 control the direction and strength of the orientation signal for the gyroscope. The PRL 20 controls the direction of the synchronisation signal. To vary the strength of the synchronisation signal it is either fed directly from the supply voltage or via a series resistance. The PRL16 and PRL21 translate the position of the clutch and the input from the “Richtungsgeber” into inputs for the orientation strength control while the PRL17 provides an output signal to operate the motor in the PFK/f4 “Führertochterkompaβ”.

A variable resistor is mounted in the bottom compartment that can be reached via an adjustment hole in the casing. This resistor regulates the turning speed of the “Kursmotor” at 2 degrees per second.

The gyroscope in its cardanic mount fills most of the top compartment. The windings of the asynchronous orientation drive can be seen at the base of the cardanic mount. The cardanic mount itself contains the contacts discs to control the synchronisation. A number of rotating contacts connect the electrical contacts so that the subframe can move freely.

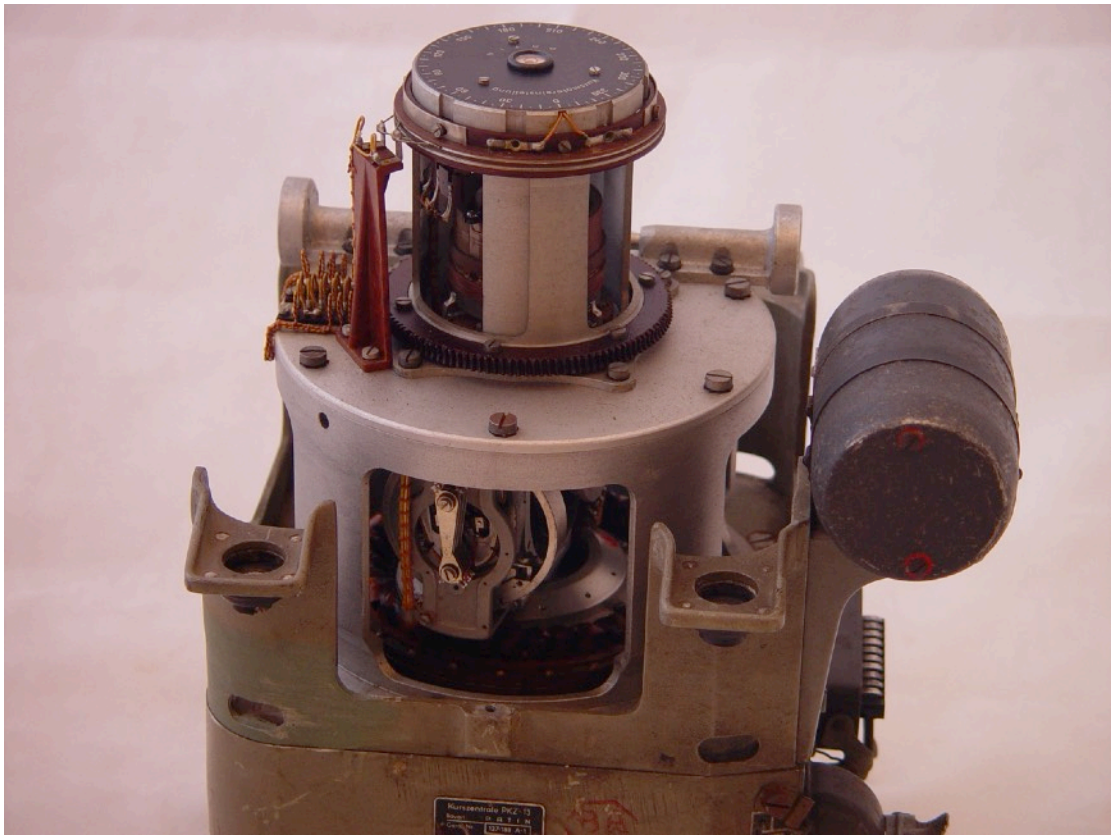

Figure 16: the top compartment of the PKZ 13 "Kurszentrale" with the gyroscope mounted below and the output resistor/clutch assembly on top.

On clutch and output potentiometer assembly is mounted on a separate subframe on top of the gyroscope assembly. A worm wheel connected to the “Kursmotor” rotates the clutch and output potentiometer assembly. The rate of rotation can be observed (and adjusted with the potentiometer fitted to the bottom section) with the 360 degree scale fitted to the top of the assembly.

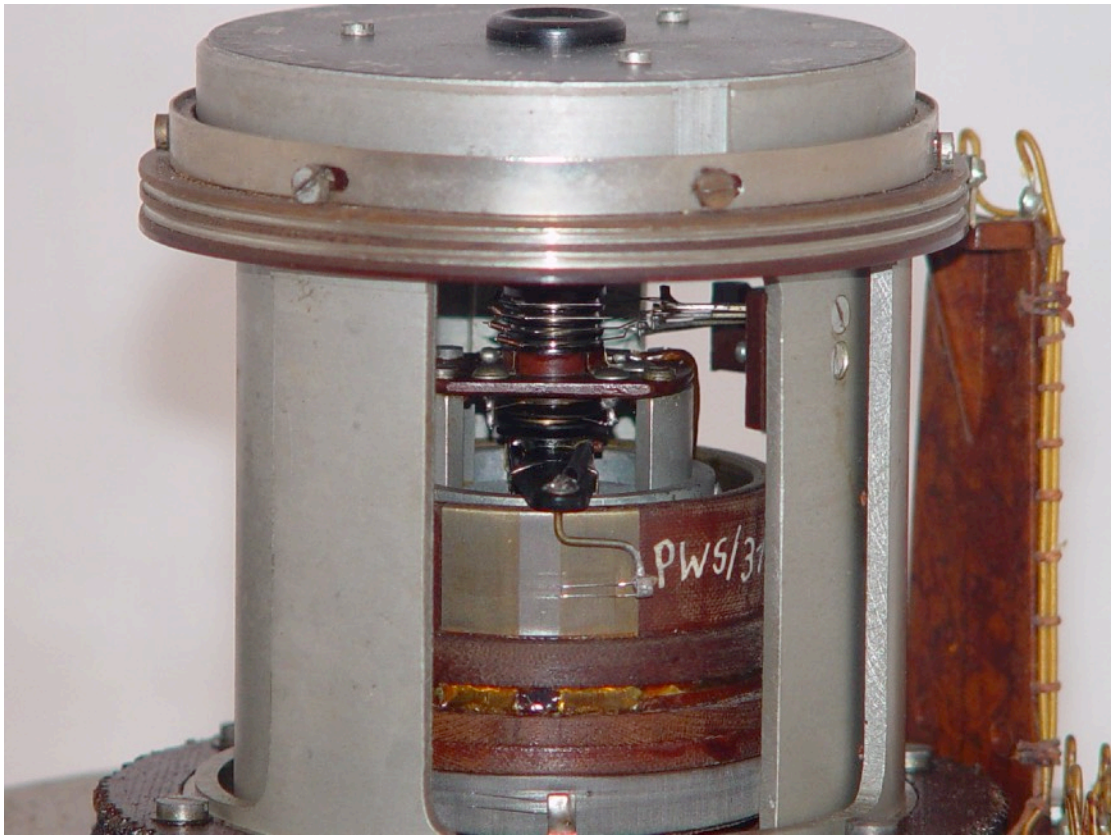

Figure 17: Close up of one of the output potentiometers. The clutch sits in the top section, fed via the two slop rings.

A transformer couples an amount of 500 Hz supplied by the “Drehstrom Umformer” into the Patin compass signals received and transmitted by the unit. This was probably an attempt to vibrate the compass system and so reduce friction and increase sensitivity but it is doubtful that this had much of an effect.

Overall the PKZ 13 “Kurszentrale” is a complex assembly with a multitude of fragile electrical contact sliders. Patin really pushed the rotating relay technology to the limit with the six interconnected PRL relays plus the various Patin receivers and transmitters. All the electromechanical elements have been made to extremely fine tolerances, which must have made the PKZ 13 “Kurszentrale” an expensive unit to make. The complexity also precluded any field maintenance of the unit, if the unit gave problems it had to be exchanged and the faulty unit returned to the factory.

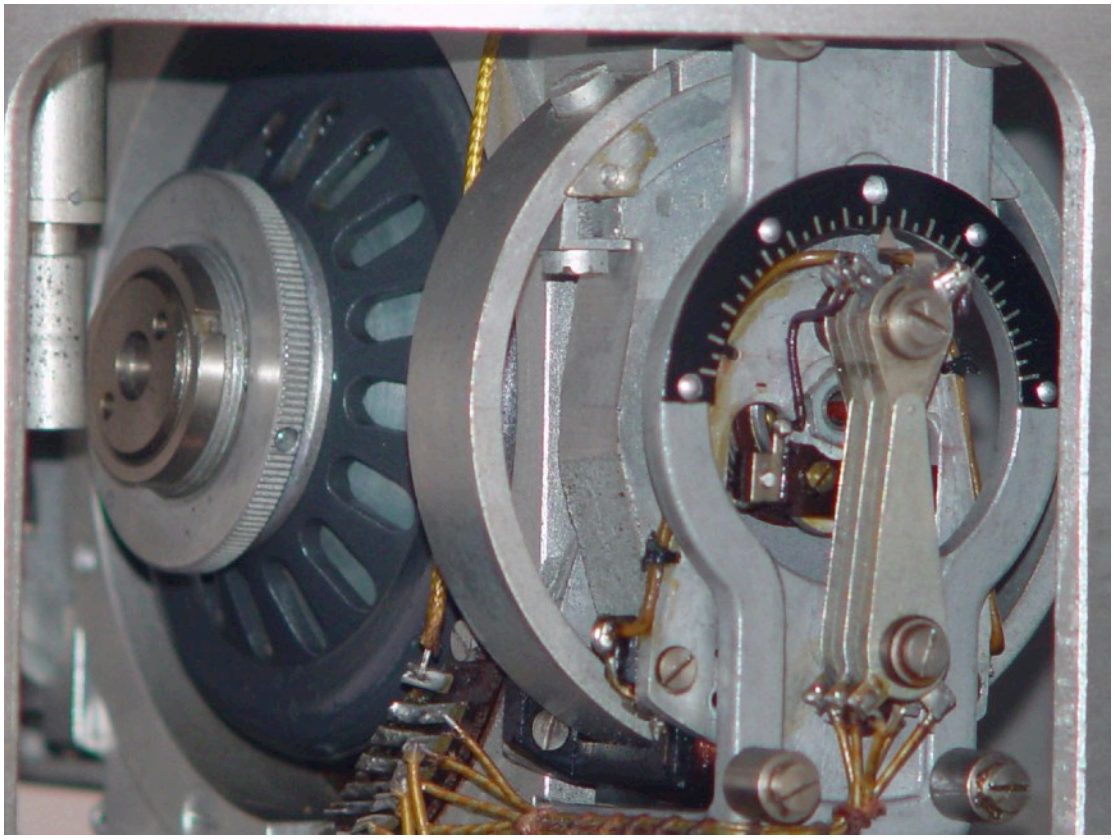

Figure 18: the gyroscope of the PKZ 13 "Kurszentrale" in its cardanic support. The assembly hides the weights and contact discs. Just visible is one of the coils around the circular core of the alignment drive.

Another issue found with the early “Kurszentrale” was that during a curve, a small error would be introduced in the heading of the gyroscope due to the roll angle of the aircraft. As a result the signal to the autopilot would increase, in turn increasing the turning rate of the aircraft requiring an even greater roll angle. This “oversteering” effect would be more pronounced in faster aircraft requiring higher roll angles.

The PKZ 14 “Kurszentrale”

Even though the PKZ13 proved that the concept worked, it was too expensive and fragile so Patin was asked to develop a simplified and improved version of the “Kurszentrale”

The principal functionality of the PKZ14 remained the same, but the number of PRL relays was reduced to only two. The PRL 18 and 20 were retained while the function of the other relays was performed by standard telegraph type relays.

The Patin compass receiver was placed offset from the main axis of the unit, this allowed the overall height to be removed from 35 to 26 cm. The gyroscope unit was moved to the bottom compartment while the Patin receiver, clutch assembly with output potentiometer and brush contacts were

all moved to the top compartment. The far smaller logic control with relays and resistors was also moved to the top compartment with a large bank of capacitors filling up the remaining space.

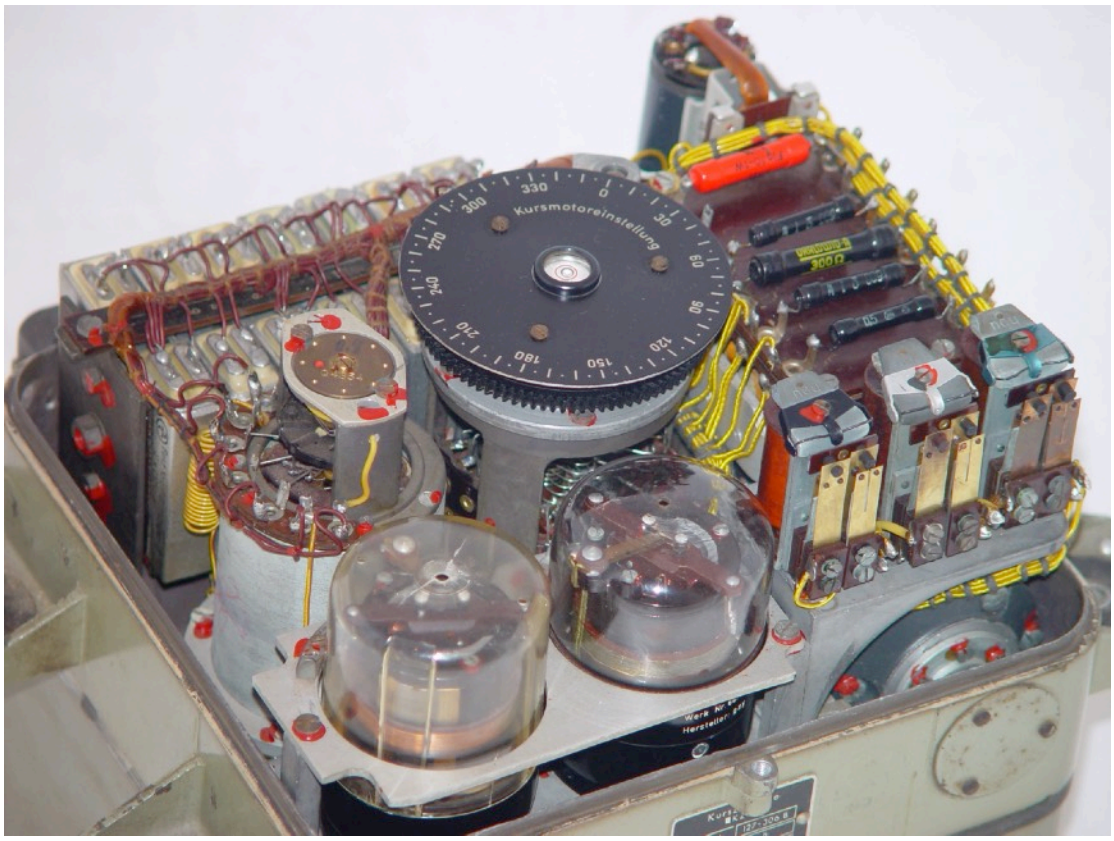

Figure 19: the top compartment of the PKZ 14 "Kurszentrale". Note the Patin compass repeater offset centre left and the two remaining PRL relays. The other relays are place front right with the "Kursmotor" underneath.

The gyroscope itself was replaced with a heavier, more stable unit and the smaller Siemens "Kursmotor" was used instead of Patin's own unit and integrated into the interior of the "Kurskreisel".

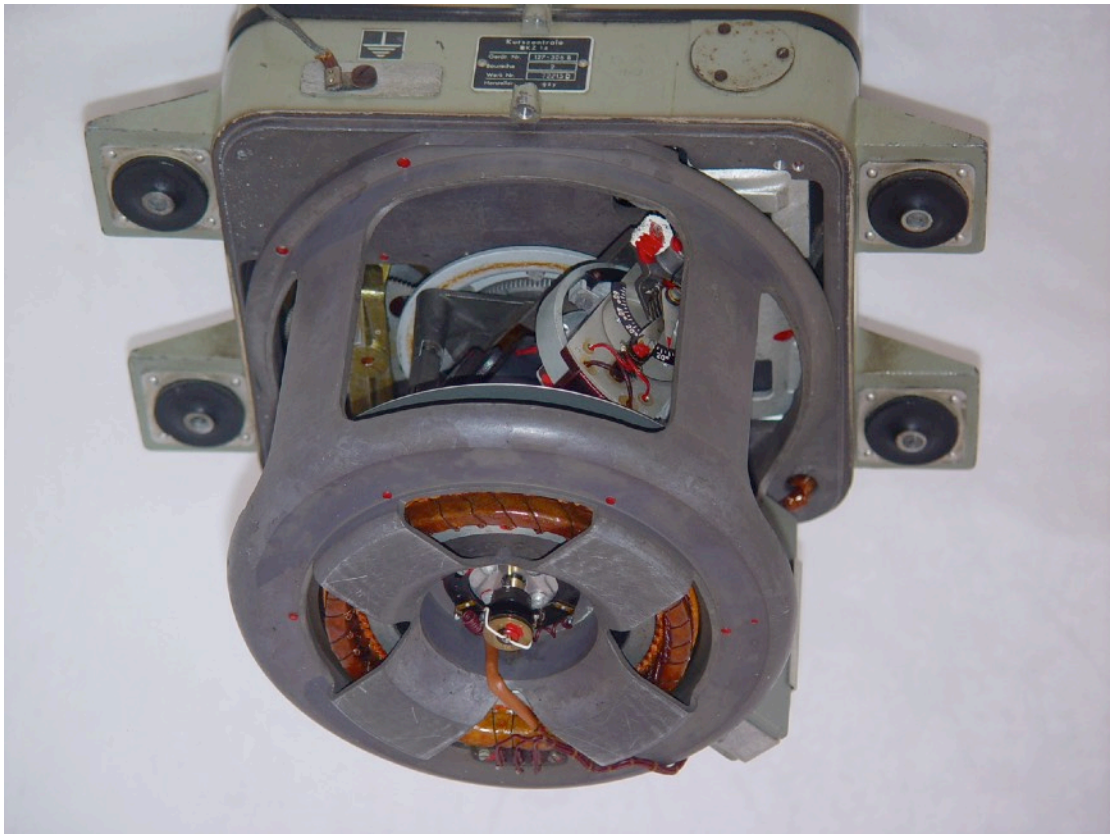

Figure 20: Bottom section of the PKZ 14 "Kurszentrale" showing the gyroscope in the centre. Note the windings of the asynchronous orientation drive around the base of the unit. Also note the small Patin compass transmitter (to transmit the gyroscope heading) in the centre of the base.

The runner and contact plate mechanism for the orientation of the gyroscope was simplified. The central section of the contact plate was now a wound potentiometer, which automatically reduced the orientation signal strength if the horizontal axis of the gyroscope was near its setpoint.

To fix the “oversteering” effect of the PKZ13 a delayed drop-off relay was introduced that temporarily disengaged the output signal to the autopilot. The time delay is achieved by using a “Schaltverzögerungsmotor” (a small DC motor running a flywheel) in parallel with the relay.

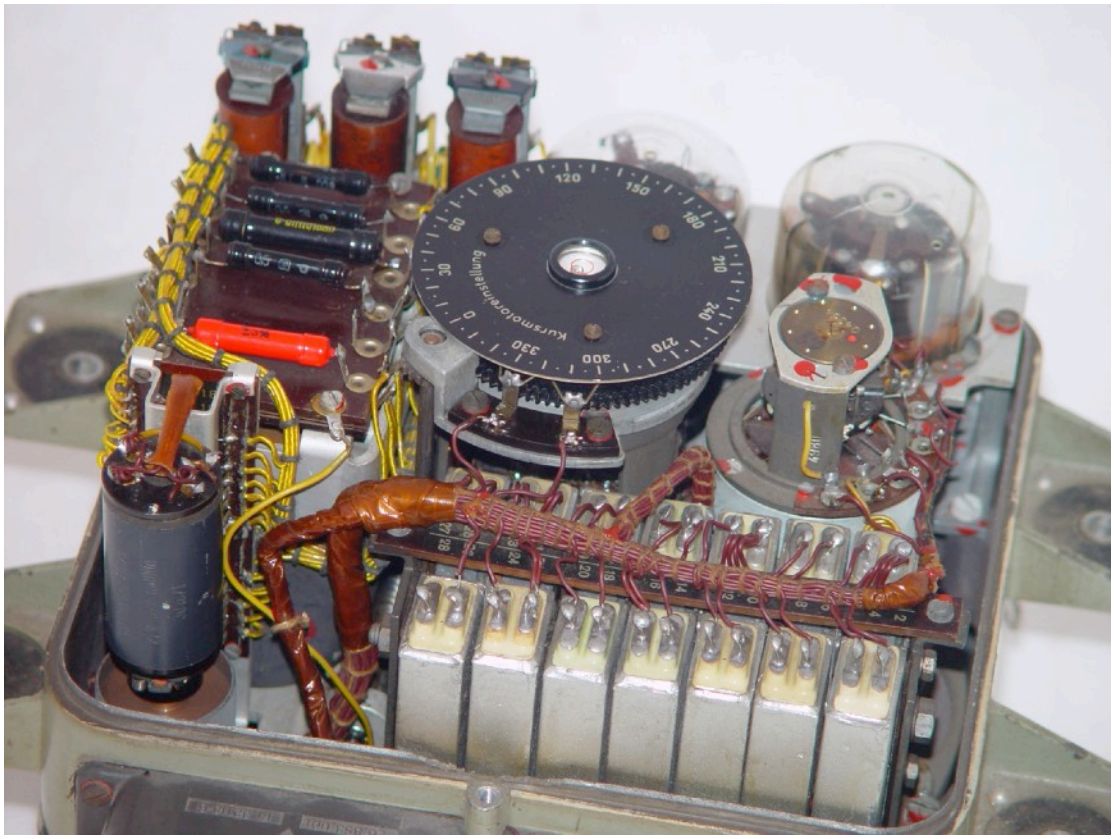

Figure 21: The other side of the top compartment. The "Schaltverzoegerungsmotor" is front left. Note the large capacitor bank front right.

When switching on, the output potentiometers are disengaged from the movement of the gyroscope and held in their central position providing a zero signal to the autopilot for the duration of the curve. The autopilot will turn the aircraft purely on the “Vorgabe” signal from the “Richtungsgeber” at a constant rate.

At the same time the orientation of the gyroscope is decoupled from the frame (which is now at the roll angle rather than true vertical) and compensated to keep the gyroscope truly vertical.

When the curve has ended, the “Schaltverzögerungsmotor” delays the re-engagement of the output signal for about 5 seconds (this allows the “Mutterkompaß” to settle down and the gyroscope to be brought back into synchronisation). After about 5 seconds the output signal to the autopilot is re-engaged and the aircraft continues flying on the new heading.

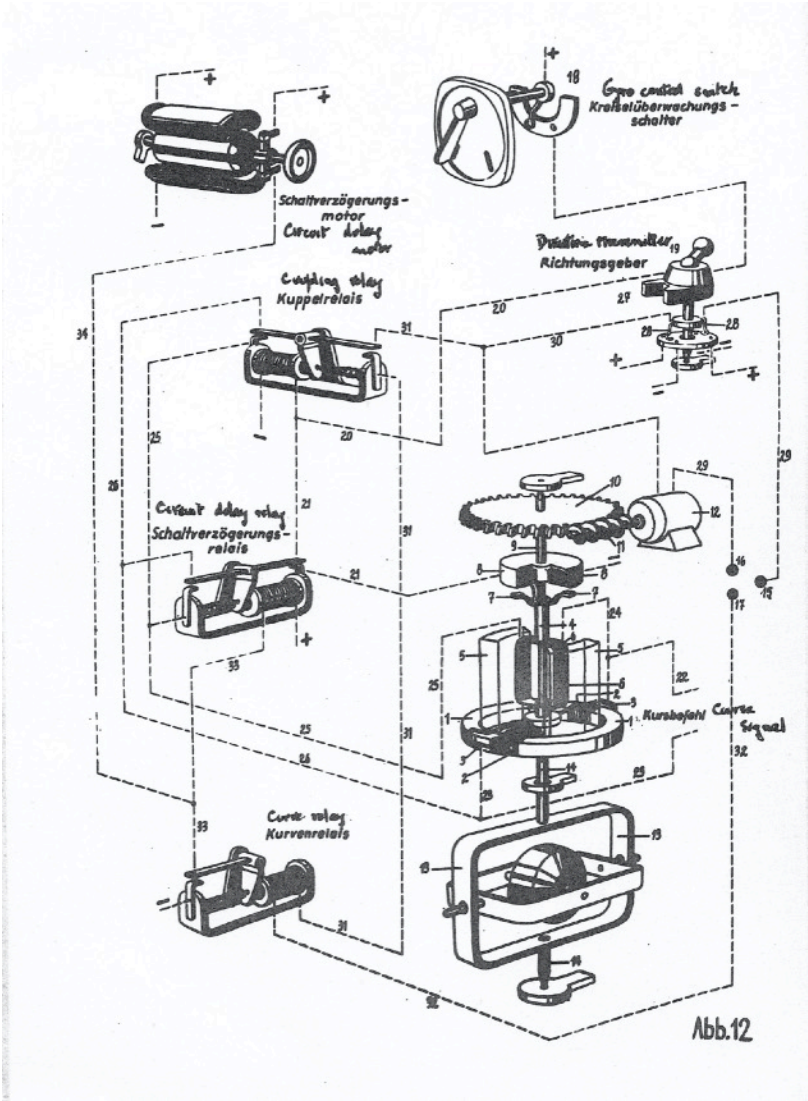

Figure 22: Schematic explanation of the circuit to prevent the "oversteering" issue.

The output relay to steer the motor of the PFK/f4 “Führertochterkompaβ” was removed. The PFK/f4 could still be used, but its motor was simply activated when the autopilot was engaged.

The 500 Hz vibration of the compass signals was no longer applied in the PKZ14 “Kurszentrale”. To reduce radio interference, all electrical connections to the PKZ14 Kurszentrale are fitted with capacitive filters.

The reduction in the number of Patin relays and the simplification of the orientation mechanism reduced the number of fragile contacts significantly which can only have benefitted the overall reliability of the unit. The reduced height and internal “Kursmotor” make the PKZ 14 a much more compact unit.

More importantly the teething problems, in particular the “oversteering” issue, were fixed, and the new PKZ14 “Kurszentrale” remained in active service for the duration of the war.

Operating the “Kurszentrale” with the autopilot

Note: There are some small differences in operating the PKZ13 and PKZ14. The different terms for the PKZ14 are indicated between brackets ().

Before start switch the “Kreiselüberwachungsschalter” to position “normal”. Switch on all the electrical supplies to the Patin PKS11 autopilot and the Patin compass system. Switch the “Hauptschalter” to position “1” and ensure that the “Kuppelschalter” on the “Richtungsgeber” is switched to the “aus” position.

After about 10 seconds, switch the “Kreiselüberwachungsschalter” to “schnell” (“Kompaβ”). After about 20 seconds, switch the “Kreiselüberwachungsschalter” to “normal” (“Kreisel”) and check that the course indicated on the “Führertochterkompaβ” remains the same. If not, switch back to “schnell” (“Kompaβ”) and repeat the process until the indication remains identical.

Switch the “Kreiselüberwachungsschalter” to “normal” (“Kreisel”).

Test the operation of the PKS11 autopilot as described in the relevant section.

In flight, the aircraft is trimmed and before engaging the autopilot, the synchronisation of the “Kurszentrale” is checked by quickly switching the “Kreiselüberwachungsschalter” between the “schnell” (“Kompaβ”) and “normal” (“Kreisel”) positions. The “Kreiselüberwachungsschalter” can now remain on “normal” (“Kreisel”).

Switch on the autopilot by moving the “Hauptschalter” to position “2” and switch the “Koppelschalter” on the “Richtungsgeber” to the “ein” position. If a PFK/f4 “Führertochterkompaβ” is fitted, the indicator will automatically align itself with the 12 o’clock position. With the PFK/f2, adjust the instrument manually.

The pilot now just has to control the roll and pitch of the aircraft.

If the course needs to be changed, the pilot can do so by operating the “Richtungsgeber” on the control column. The first position of the “Richtungsgeber” causes a turn rate of 1 degree per second, the second position a turn rate of 2 degrees per second (on earlier installations of 2 and approximately 3 degrees per second respectively). The Pilot has to manually control the roll angle during the curve.

At the end of the curve, the “Richtungsgeber” is switched back to the central position and the pilot brings the aircraft back into a horizontal position.

The bomb aimer can take control by sliding the switch on his LRG5 or LRG15 controller to the “ein” position. The pilot should get an indication that the bomb aimer has taken control. To avoid any movements due to the synchronisation system, the pilot switches the “Kreiselüberwachungsschalter” to the “offen”

position (this facility is not available on the PKZ 14 “Kurszentrale”). The bomb aimer now controls the heading of the aircraft with the pilot controlling the roll if required.

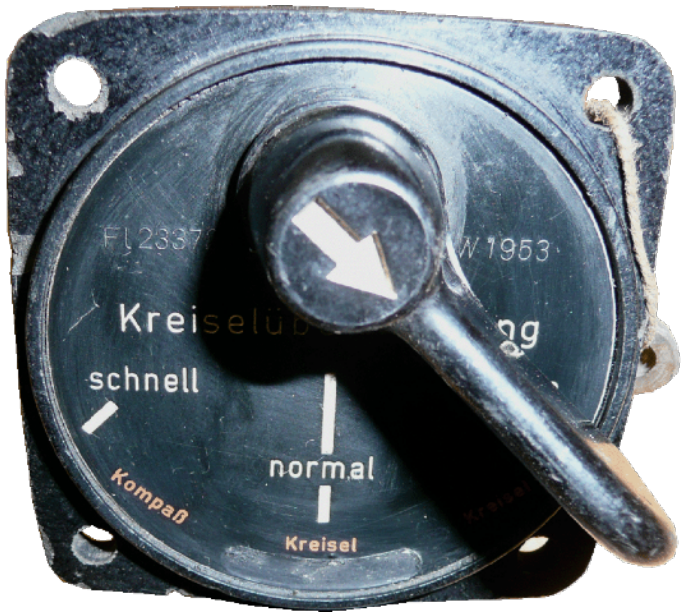

Figure 23: "Kreiselueberwachungsschalter" switched to the "offen" positon. This was only available on the PSH 11 as used with the PKZ 13 "Kurszentrale"

If circumstances require the pilot to take evasive action the PKS11 autopilot is switched off by turning the “Koppelschalter” on the “Richtungsgeber” to the “aus” position. While the pilot flies the evasive action, the original heading remains at the 12 o’clock position of the PFK “Führertochterkompaß”. After the evasive action, the pilot can either manually return to this original heading or decide to fly on a different heading.

When the PKS11 autopilot is re-engaged by switching the “Koppelschalter” to the “ein” position, the autopilot will retain whatever heading that is being flown at that moment and the PFK/f4 will turn that current heading to the 12 o’clock position.

The autopilot can be disengaged by:

a) switching the “Koppelschalter” on the “Richtungsgeber” to the “aus” position
b) switching the “Kreiselüberwachtungsschalter” to the “schnell” (“compass”) position
c) switching the “Hauptschalter” to the “1” position
d) switching off the electrical supply to the PKS11 autopilot

After landing, switch the “Hauptschalter” to the “0” position and switch of all electrical supplies.

Any faults with the automatic pilot should be reported to ground staff.

The “Kurszentrale” demonstration rig

Figure 24: Overview of the "Kurszentrale" and K12 demonstration rig

In order to demonstrate the “Kurszentrale”, the K12 demonstration rig was modified to include a PKZ14 “Kurszentrale”. Although more typically used with the PKS11 autopilot, the “Kurszentrale could be used with the Siemens K12, in a variant known as the “K12-7”.

As before, the “Mischgerät”, “Wiederstandskasten”, “Rudermaschine” and “Drehstrom Umformer” are placed at the back of the rig. The PKZ14 “Kurszentrale” is placed in the front part of the rig. The instrumentation on the headboard is simplified with only a PFK/f1 “Führertochterkompaβ” and a late model “Kreiselüberwachungsshalter”.

Figure 25: "Kurszentrale" mounted in the front part of the dmeonstration rig. Note that the “Kurszentrale has actually been oriented 90 degrees from the direction of flight axis (the arrow on the perspex window should point backwards) but this makes no difference in the demonstration rig.

For demonstration purposes a LKZ 3 “Kurszieger” and an electric turn indicator have been added although these are not typically part of the installation.

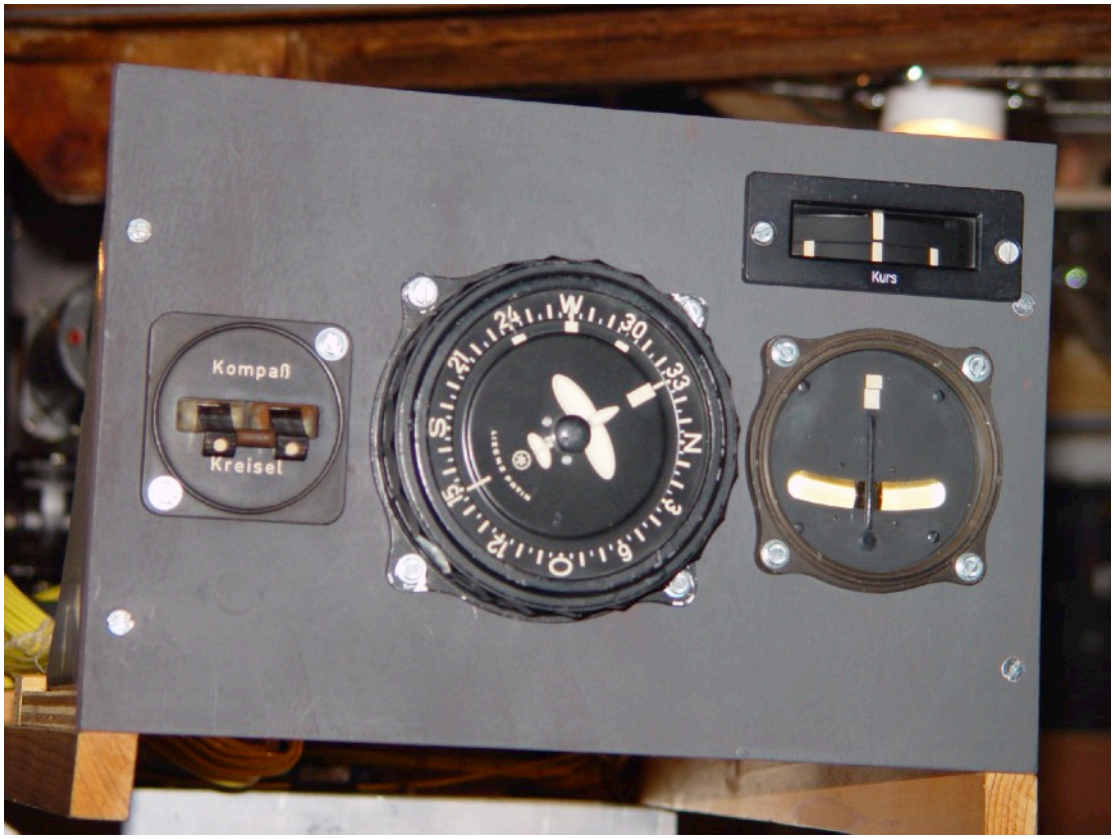

Figure 26: Instrument cluster on the "Kurszentrale" demonstration rig. Normally on the the PFK "Fuehrertochterkompaβ" would be required on the instrument panel.

A demonstration rig with the PKZ13 and early PKS11 autopilot is still in preparation. The PKZ13 “Kurszentrale” including “Mutterkompaβ”, “Kreiselüberwachungsschalter” and PFK/f4 “Fuehrertochterkompaβ” are electrically connected to an early “Steuerkasten” of the PKS11. A LKZ 3 “Kuszeiger” is used to show the output signal of “Steuerkasten” so that the role and functioning of the different units can be demonstrated separately.

Figure 27: Late war type PSH 17 "Kreiselüberwachungsschalter" used with the PKZ 14 "Kurszentrale"

Operating the “Kurszentrale” demonstration rig

The rig can be operated as described in the “Operating the “Kurszentrale” with the autopilot” section.

As the “Hauptschalter” is moved to the “1” position, the “Drehstrom Umformer” springs to life, and the gyroscopes start to run up.

If the “Kreiselüberwachungsschalter” is left in the “Kreisel” position and the demonstration rig was moved during standstill, there is a chance that the heavy gyroscope in the “Kurszentrale” swings wildly against its mechanical end stops during the first few revolutions of the rotor. It is best to start the PKZ14 “Kurszentrale” with the “Kreiselüberwachungsschalter” in the “Kompaβ” position, so that the orientation and synchronisation forces keep the swinging at startup under control.

After running up for a minute, the “Kreiselüberwachungsschalter” can be switched between “Kompaβ” and “Kreisel” to check synchronisation. If the “Führertochterkompaβ” no longer shows a difference between the two positions, the “Kurszentrale” has synchronised itself and the “Kreiselüberwachungsschalter” can permanently be left on “Kreisel”.

After moving the “Hauptschalter” to the “2” position, the “Rudermaschine” starts and the autopilot is ready for action.

When the “Koppelschalter” on the “Richtungsgeber is switched to the “ein” position, the autopilot is engaged and keeps the demonstration rig on the current heading. If the rig is disturbed by hand, it will automatically return to the original heading.

If the disturbance is greater than 30 degrees, the autopilot will not return to the original heading. The output potentiometers in the “Kurszentrale” are designed to operate over +/- 30 degrees from the setpoint. If the disturbance exceeds this range, one of two end contacts on one of the output potentiometers will momentarily open allowing the electrical clutch to slip. This slip changes the set heading and prevents the output potentiometers from being damaged. In practice however, disturbances of this magnitude should not normally occur.

The rig can be turned by engaging the “Richtungsgeber”. At the first position, the rig starts turning at 1 degree per second, at the second position it turns at 2 degrees per second. The “Schaltverzoegerungsmotor” in the “Kurszentrale” can clearly be heard running up when the “Richtungsgeber” is engaged.

If the “Koppelschalter” is switched to the “aus” position, the autopilot is immediately disengaged and the output lever of the “Rudermaschine” stops moving. The rig can now be turned by hand onto a new course. When the “Koppelschalter” is switch back to the “ein” position, the autopilot re-engages and keeps the rig on the new course.

At the end of the demonstration, the “Koppelschalter” is switched to the “aus” position and the “Hauptschalter” moved back first to the “1”, then to the “0” position. The “Rudermaschine” stops and the gyroscopes will start running down. The heavy gyroscope in the “Kurszentrale” keeps the “Drehstrom Umformer” turning for at least half a minute before slowly running down.

The yet incomplete PKZ 13 demonstration rig can similarly be run up. After letting the gyroscopes gain speed, the synchronisation can be checked by switching the “Kreiselueberwachungsschalter” between the “schnell” and “normal” positions.

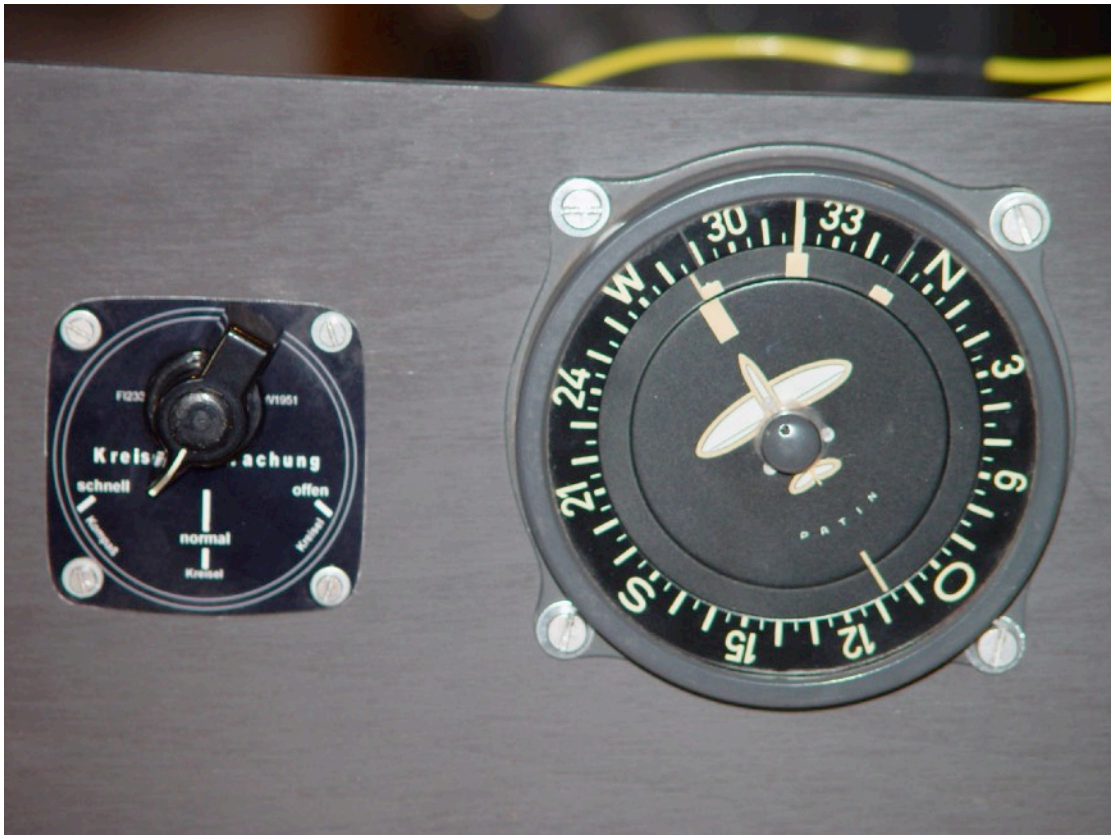

Figure 28: With the "Kreiselüberwachungsschalter" on "schnell", the "Mutterkompaß" has been turned by hand. The PFK/f4 "Führertochterkompaß" shows a deviation from the set course.

The working of the PFK/f4 “FührertochterkompaB” can be demonstrated by moving the “Kreiselueberwachungsschalter” to the “schnell” position, and turning the “MutterkompaB” by hand. The compass indicator will change couse accordingly. If the “Richtungsgeber” is now engaged, the compass will turn the indication to the 12 o’clock position. This functionality is specific to the PKZ 13 and its specific output relay to control the PFK/f4.

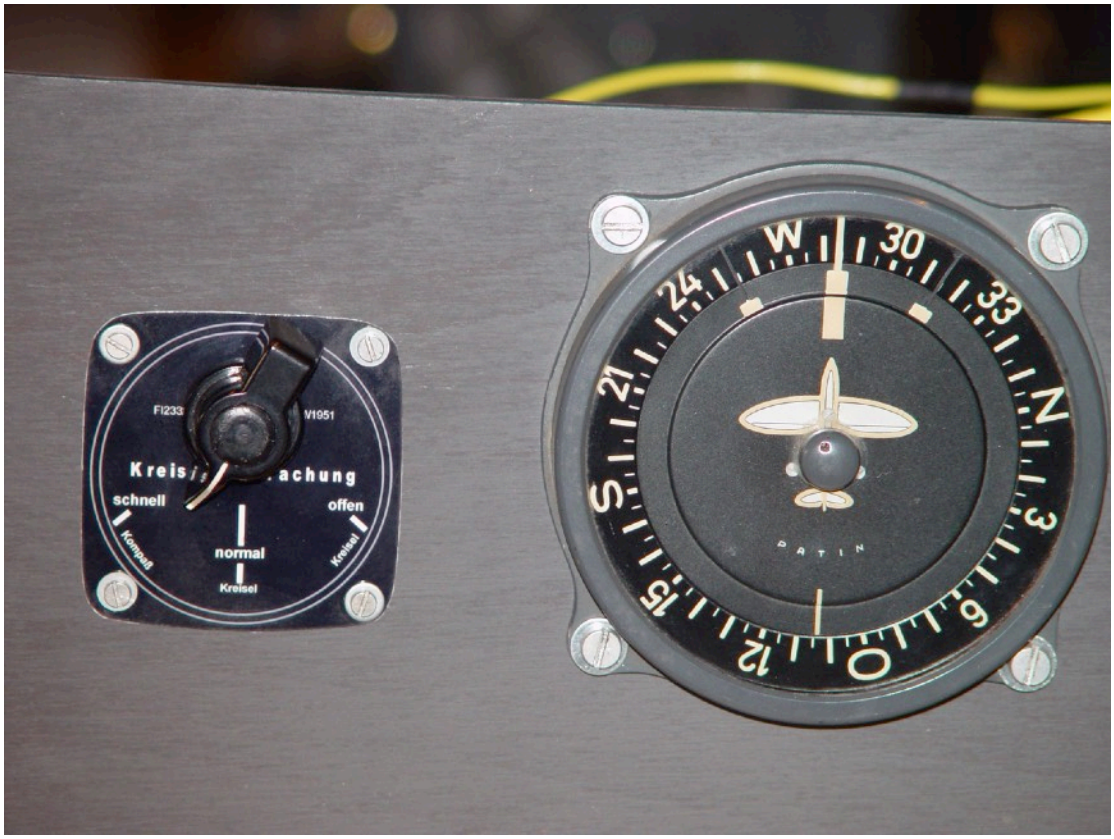

Figure 29: With the "Kreiselüberwachungsschalter" still in the "schnell" position, the "Richtungsgeber" is engaged causing the indication on the PFK/f4 to turn to the 12 o'clock position.

If the “Kreiselüberwachungsschalter” is turned back to “normal” quickly, the difference between the “Mutterkompaß” and gyroscopic indications can be observed. By switching between these two positions, the speed of synchronisation can be observed as the two indications get gradually closer.

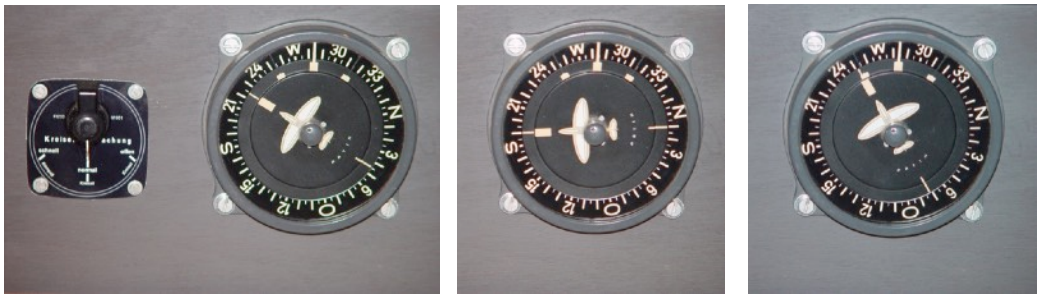

Figure 24: Repeated switching the "Kreiselüberwachungsschalter" between "schnell" and "normal" shows how the "Kurszentrale" is synchronising at about 1-2 degrees per second.

In some instances, the speed of the “Drehstrom Umformer” can be heard to reduce slightly when the “Kreiselüberwachungsschalter” is switched to “schnell”. This is an indication that the gyroscope in the PKZ13 is being oriented. After a few seconds the “Drehstrom Umformer” returns to its full running speed indicating that the orientation is complete.

With the synchronisation and the orientation complete, the “Kreiselüberwachungsschalter” is switch to “normal” and left there. The “Koppelschalter” is now moved to the “ein” position. If not yet aligned, the PFK/f4 indicator will turn the set course to the 12 o’clock position and keep it there.

If the “Mutterkompaβ” is now turned by hand, the indication of the “Kurszentrale” will change very slowly (at about 1 degree per minute). This changed is best observed on the LKZ 3 connected to the “Steuerkasten”, which will slowly but visibly run out of the centre. The output signal of the “Kurszentrale will slowly change because, as it slowly follows the “Mutterkompaβ”, the gyroscope turns in relation to the fixed setpoint.

When the “Koppelschalter” is disengaged, the LKZ3 jumps back to the central position, showing that the clutch in the “Kurszentrale” is disengaged and that the output potentiometers are being held in the central position. If the “Kurszentrale” is turned by hand now, the LKZ 3 stays in the central position.

If the “Kurszentrale” is turned by hand with the “Koppelschalter” switched back on however, the turning of the “Kurszentrale” will show a proportional indication on the LKZ 3 “Kurszieger”. When the PFK/f4 “Führertochterkompaβ” is observed during these turns, the course indication changes and the instrument immediately starts turning the indicator ring so that this course keeps pointing towards the 12 o’clock position. If the “Koppelschatler” is switched back to “aus” position the movement of the indiciator ring stops but the course indication keeps changing with the turning of the “Kurszentrale”.

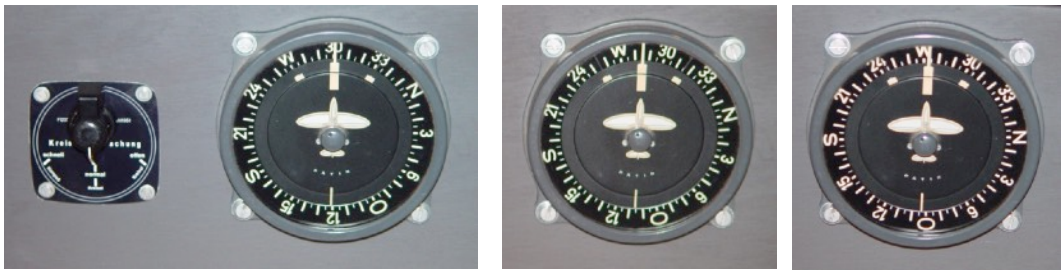

Figure 30: With the "Koppelschalter" engaged the “Kurszentrale” is turned by hand. The motor in the PFK/f4 "Fuehrertochterkompaβ"

Now the electrical supplies can be switched off and the gyroscope will start their run down.

What is amazing is that this technology can still be made to function as intended, more than 70 years after it was manufactured and years of neglect!