Patin PKS11 autopilot

Patin PKS 11

Introduction

While Siemens was focussed on the developments based on the K4 system, the Askania firm was manufacturing pneumatic system at first based on the Sperry gyropilot, later of a more advanced designs.

From about 1935, the “Erprobungsstelle der Luftwaffe” in Rechlin became involved in evaluating and developing autopilot systems. One of the ideas pursued by the Rechlin department was that the rate of adjustment of the rudder, rather than the rudder angle was the more important parameter to control. This was called dynamic control of the rudder and in 1935 a patent was granted for a new autopilot based on this principle. A new damping gyro was developed that produced electrical signals for both the rate of turn and the angular acceleration. These electrical signals were fed to a Ward-Leonard transformer that fed the signals to an electrical rudder motor.

In 1936, the “ReichsLuftfahrMinisterium” (RLM) initiated a competition for a new three-axis autopilot. Askania entered their Lst 14c autopilot, while Siemens entered their D III and D IV autopilots. The third party to enter was the Rechlin department with their “Rechliner dreirudersteuerung” (three rudder controller).

After an extensive testing program, it became clear that the pneumatic technology used in the Askania Lst 14c showed serious shortcomings in the ever faster and higher flying aircraft of the time and was eliminated from the competition. After disappointing results with their D III and D IV systems, Siemens entered their DK 4 autopilot, based on the three “Rudergetriebes” from the K4. The Rechlin team was also not idle and further improved their system with the aid of the Patin company.

At the end of the competition in 1939 the “Rechliner dreirudersteuerung” was found to be marginally superior to the Siemens system and Askania was given the task to develop a production version of the Rechlin system.

The developments of the system by Askania quickly ran into trouble due to internal friction and after some months the development and manufacture of the new autopilot was transferred to the Patin company.

The series production version of the Rechlin system became known as the “Patin-Dreirudersteuerung” (PDS) and with it the first all-electrical autopilot was born.

To speed up the introduction of the new system, Patin first focussed on the course control part of the PDS. This one-axis autopilot became known as the “Patin-Kurssteuerung” PKS11. The PKS11 became available in 1940 and was applied in a multitude of Luftwaffe aircraft: Ju 188, Ju 288, Ju 388, Ju 252, Ju 352, Ju 290, Me 210, Me 264, Me 410, Si 204, Do 217 and Do 335.

Description of the PKS11 autopilot

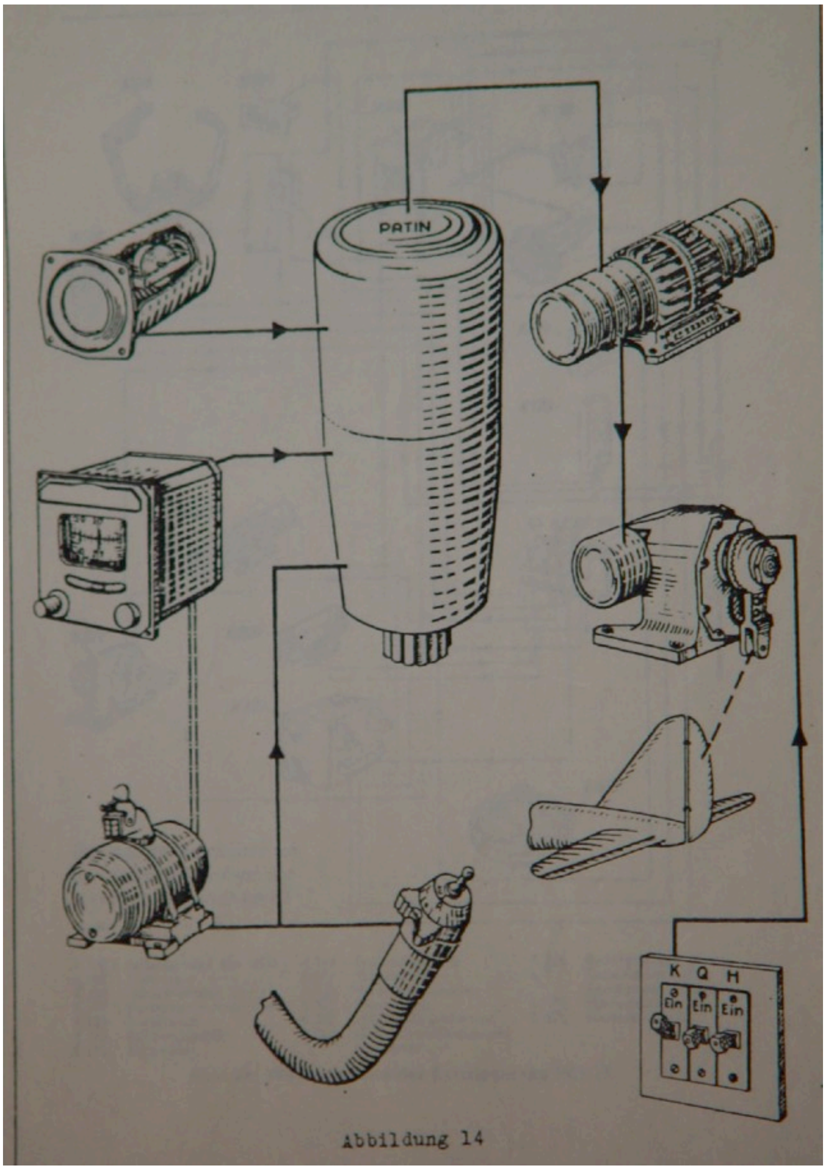

Figure 1: Patin PKS11 autopilot overview

Apart from the aforementioned Patin master and daughter compass, the PKS11 consists of -

- a LKu 4 “Kurskreisel” directional gyroscope,
- a LKz 3 “Kurszieger” indicator,
- a Lri 2 or Lrg 12 “Richtungsgeber” course adjustment switch,
- a LKMm “Kursmotor” course adjustment motor,
- a PDS “Steuergeraet” or SK 11 “Steuerkasten” control unit,
- a “Leonard Umformer PKS” Ward-Leonard converter
- a “Rudergetriebe” rudder servo
- a “Drehstromumformer” generator
- a PDR 10 “Dämpfungsregler” damping controller.
- a LSch 4ü “Hauptschalter” main switch,
- a “Stützschalter” compass coupling switch,
- a “Wiederstandskasten” resistor box.

As with the K4ü and K12 systems, different configurations of control switches could be supplied so that the system could be used for bomb aiming when required.

Again for compatibility reasons the LSch 4ü “Hauptschalter” was retained even though not strictly necessary.

A simplified “Jeagersteuerung” version was produced for “Schlechtwetterjaeger” (bad weather hunters) in which the “Kurskreisel” was replaced by a “Befehlsgeber” trim switch. The “Jeagersteuerung” can not keep a fixed course for long durations but can be used to fly through cloud cover in a straight line and could be used to keep the aircraft stable during take-off and landing.

The Functioning of the PKS11 autopilot

The principles of the autopilot

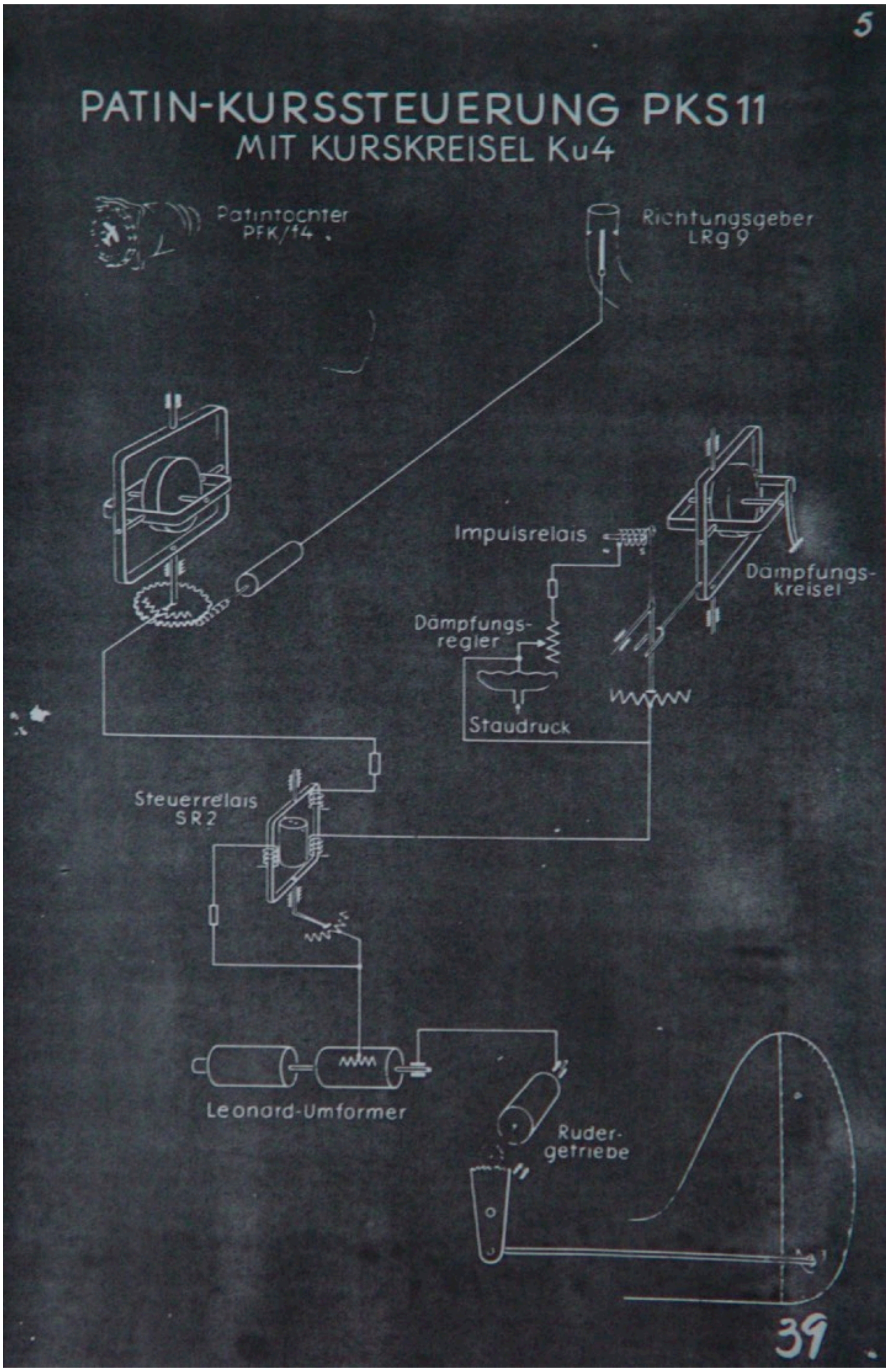

Figure 2: Functional overview of the PKS11 autopilot

The PKS11 autopilot has a few principal differences with the Siemens K4ü and K12 systems. As discussed in the introduction, the PKS11 was conceived as a “dynamic” autopilot, controlling the speed of the rudder movement while the Siemens systems control the position of the rudder.

Where in the Siemens systems the damping of the oscillations was done by measuring the angular velocity, in the “dynamic” system the damping gyroscope included a measurement of the angular acceleration. A new type of support frame for the damping gyroscope was developed so that precession of the gyroscope now produced an electrical output signal based on both angular velocity and acceleration.

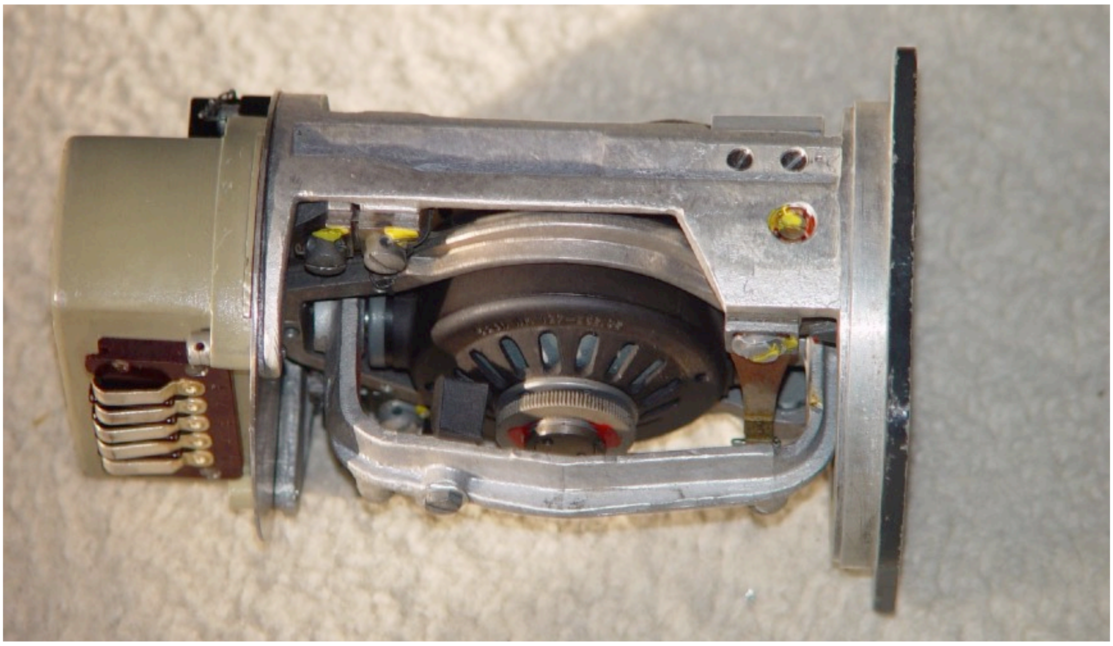

Figure 3: “Dämpfungskreisel” for the PKS11 autopilot. Note that the gyroscope is mounted in two perpendicular frames.

The new damping gyroscope did not have fixed springs to return the gyroscope to the neutral position, instead using an electromagnet powered by it’s own output voltage. By regulating the current through this “Dämpfungsimpulsrelais”, the “stiffness” of the damping gyro could be regulated. The gyroscope unit had a Luftwaffe “Geraete Nr” 127-252.1x, with the last digit (x) denoting the relative strengths of the angular velocity and acceleration in the output signal. By using the PRI 2 “Deampfungsimpulsrelais” and the different mixing ratios available, the autopilot could be adapted to different aircraft and operating requirements.

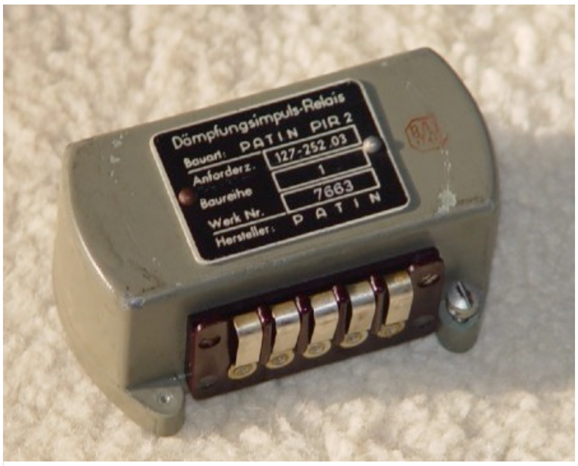

Figure 4: "Dämpfungsimpulsrelais"

The other advantage of using the “Dämpfungsimpulsrelais” was that the “stiffness” of the damping could be made dependable on the speed of the aircraft. As the speed of an aircraft increases, the effect of the rudder increases as well. At higher speeds, the autopilot can suffice with smaller rudder adjustments. An airspeed sensitive resistor unit, called the “Dämpfungsregler” was incorporated into the PKS11 autopilot design.

Those familiar with modern control theory will recognise that the “dynamic” system is essentially a Proportional – Integral - Derivative (PID) type control.

The second key difference is in the way that the electrical control signals are mixed and amplified. The Patin company had developed a series of rotational relays. These relays function akin a moving coil galvanometer (classic analog Voltmeter). If an electrical voltage is applied to a coil rotor placed in a magnetic field, the rotor will turn. Patin applied multiple coils into a single rotor and instead of an indicator attached two potentiometer wipers to the moving coil. These wipers produce an output voltage if the coil is moved left or right from a central position. For the PKS11, Patin developed the PSR-2 “Steuerrelais” which has four input windings.

Figure 5: PSR-2 "Steuerrelais"

The final key difference is that force amplification no longer uses a hydraulic actuator but an electric drive system. The output of the “Steuerrelais” is fed to the input coil of a Ward-Leonard converter. The Ward-Leonard converter consists of a DC motor, fed from the 24V supply in the aircraft, coupled to a DC generator which in turn is electrically connected to the rudder servo motor. The signal from the “Steuerrelais” is coupled to the field windings of the DC generator, this produces a proportionate and much amplified output from the armature windings which drives the rudder servo motor.

Unlike with the electro-hydraulic actuators in the Siemens autopilots, there are no end-stops to the electric servo motor. The autopilot potentially keeps driving the rudder sideways until the system sees the aircraft react to its commands. To prevent damage to the rudder controls, the “Rudergetriebe” of the PKS11 is fitted with a slip clutch, which will slip if a certain torque is exceeded. The clutch will disengage completely when it is de-energised, so it acts like the “Koppelventil” in the hydraulic rudder motors.

One disadvantage of the electromechanical technology used in the “Steuerrelais” is that it is never totally frictionless, this can result in a slight hysteresis in the autopilot causing an oscillation during flight. This effect can be countered by mechanical or electrical vibration of the “Steuerrelais”. The German pilots tended not to synchronise their engines completely in their twin-engined aircraft, causing sufficient mechanical vibration to overcome the hysteresis effect in their autopilot (and in their Patin compass repeaters which also benefit from being vibrated).

For smoother aircraft, such as single engined or jet-powered aircraft, the PWU 10 “Schüttelumformer” (literally shaking motor) could be added to PKS11 autopilot. The “Schüttelumformer” generated a small 50 Hz voltage that was fed to one of the windings in the “Steuerrelais”. The 50 Hz frequency is high enough not to cause any effect on the steering signals, yet it effectively counters the hysteresis and increases the sensitivity of the relay.

Figure 6: the "Schüttelumformer"

The Patin “Führertochterkompass” and the “Kurskreisel”

The functioning of the course setpoint determining instruments (PFK/f3 “Fuehrertochterkompass”, Lku 4 “Kurskreisel”, Lkz 3 “Kurszeiger” and LKMm “Kursmotor”) is identical as with the K4ü and K12 systems and will not be discussed here, please see the equivalent section in the K4ü chapter.

The PKS11 could also be used with the PKZ13 or 14 “Kurszentrale”.

The “Befehlsgeber”

A simplified “Jaegersteuerung” version of the PKS11 autopilot was designed for use in single engined “Schlechtwetterjaeger (bad weather hunters). This version no longer uses the LKU 4 “Kurskreisel” to create a setpoint, but instead uses a PBG-11 “Befehlsgeber” trim switch.

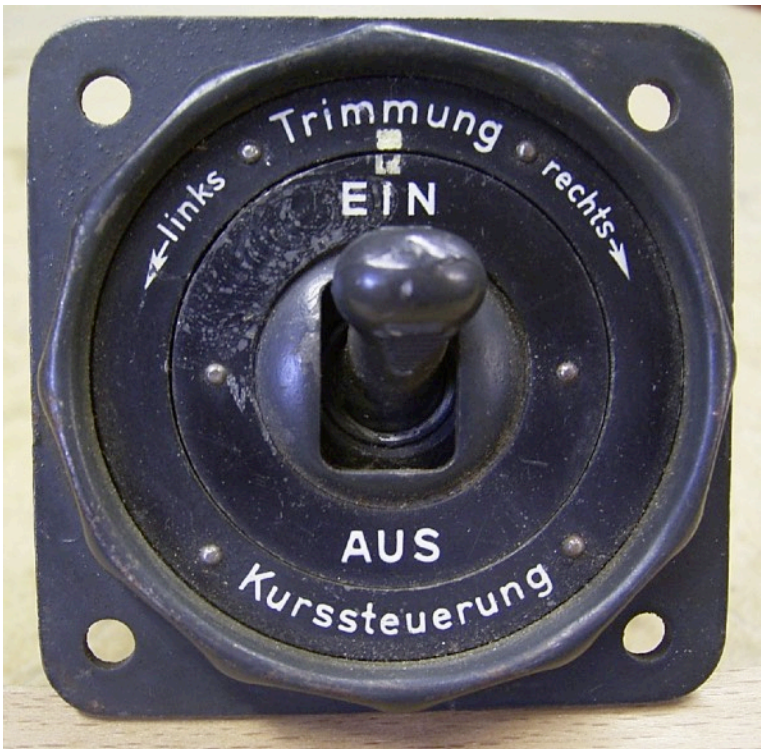

Figure 7: PBG-11 “Befehlsgeber”

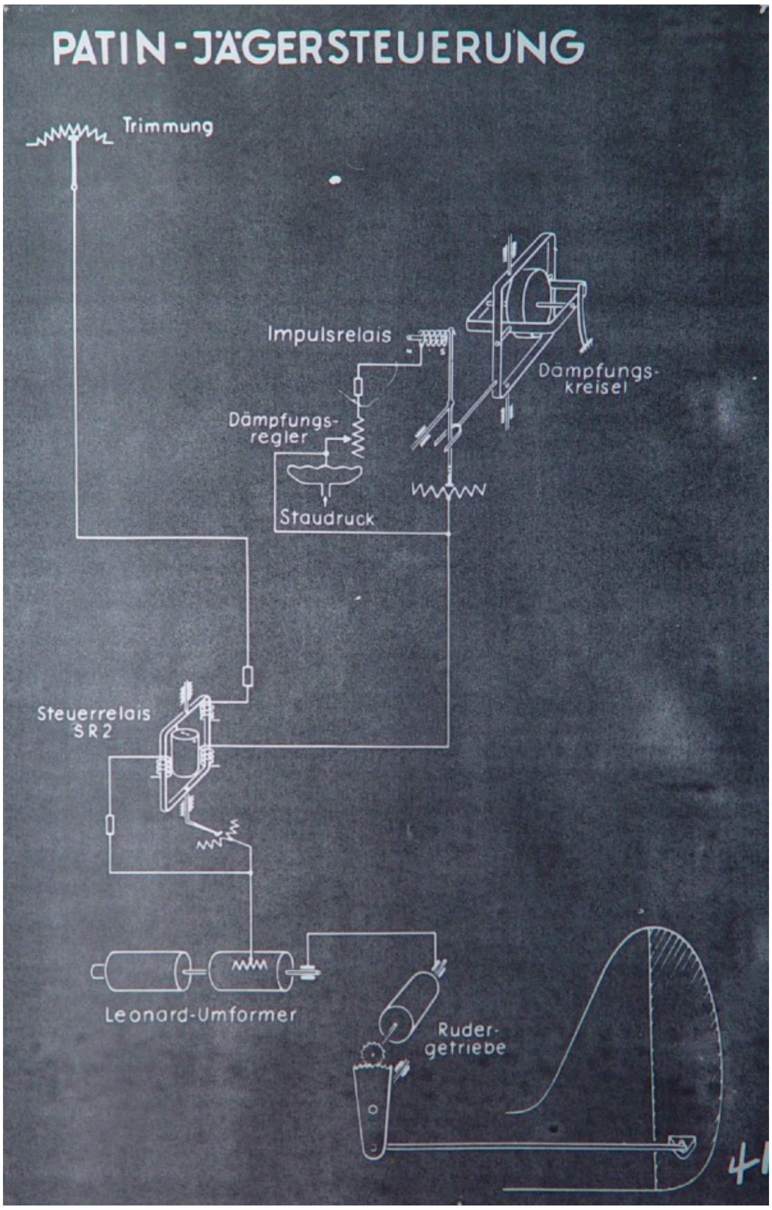

Figure 8: Overview of the simplified Patin "Jaegersteuerung" with "Befehlsgeber" (marked "Trimmung")

The “Befehlsgeber” contains a “Koppelschalter” to engage or disengage the autopilot, centered in a turnable ring to change the trim to the left or the right. The “Befehlsgeber” would be placed so that that the pilot could manipulate it with his left hand while operating the control stick with his right hand.

The “Richtungsgeber”

The PKS11 could either use the Lrg-12 of the K-12 autopilot, or use the Askania Lri 2 “Richtungsgeber”. The two types are functionally virtually identical, although early types of the Lri 2 locked in the first (1 degree per second turn rate) position rather than the second position.

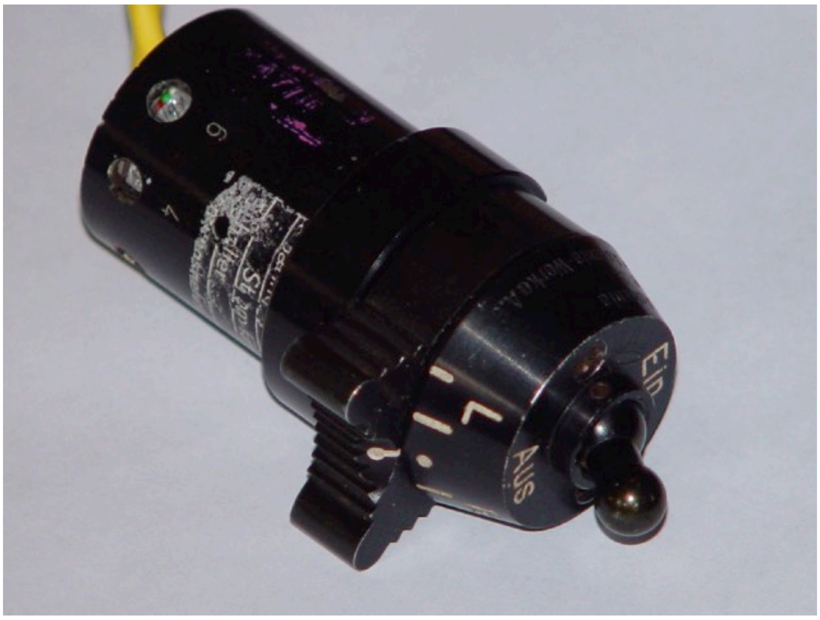

Figure 9: The Lri 2 "Richtungsgeber" made by Askania

The “Wiederstandskasten”

The “Wiederstandskasten” used by the PKS11 is a slightly different shape, containing all resistors to regulate the turning speed of the “Kursmotor”, adjust the bolometer balance of the “Kurskreisel” and it contains a series resistor for the “Kurszieger”. Separate versions exist for use with one or with two “Kurszieger”

Figure 9: PFK-f3 compass repeater. Note the absence of a bevel for manual adjustment and the twin plug sockets

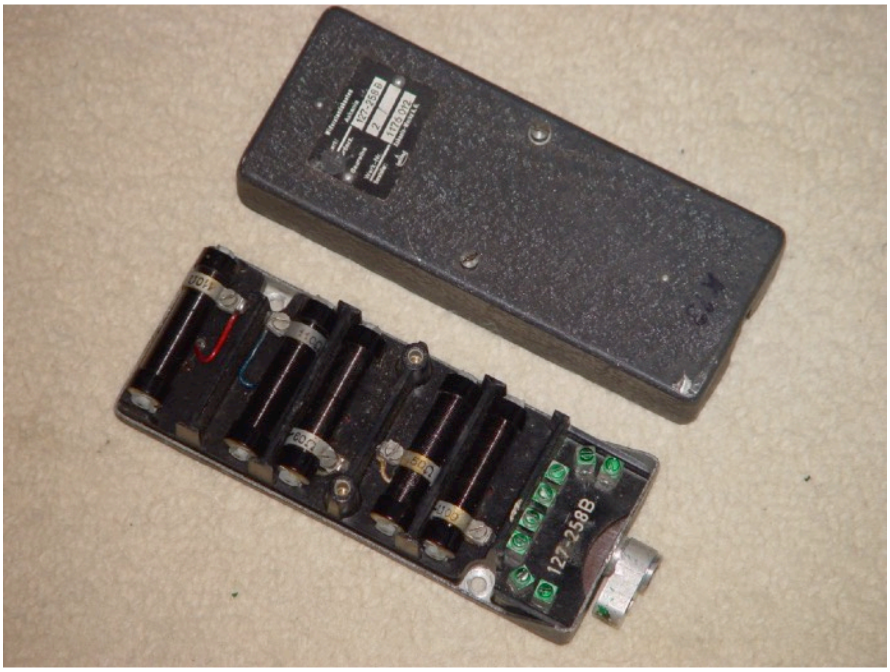

Figure 10: Early type "Wiederstandskasten" made by Askania, opened up to show the resistors inside. Note the “K13” equipment code painted on the lid.

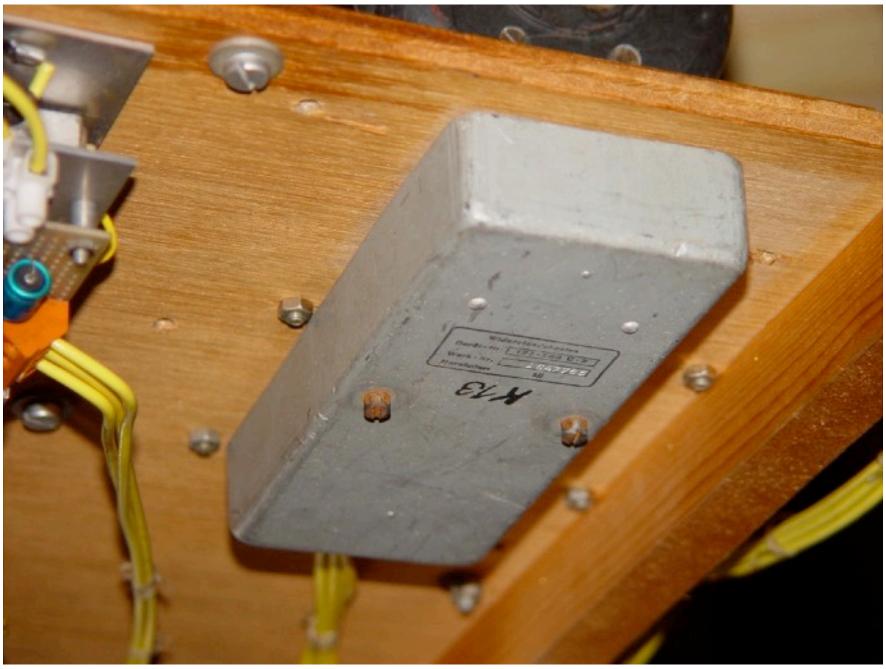

Figure 11: Later type "Wiederstandskasten" made by Patin. Note the "K13" equipment code painted on the box

The “Drehstromumformer”

Typcially, the smaller type “Drehstromumformer” would be used with the PKS11 to drive the two gyroscopes (“Kurskriesel” and “Dämpfungskreisel)”

Figure 12: 40 Watt "Drehstrom Umformer"

The “Steuerkasten”

The “Steuerkasten” or steering unit is the heart of the PKS11 autopilot.

As a stop-gap measure, early Askania made PDS “Steuerkasten” were converted. These early Askania units were designed for three damping gyroscopes and three “Steuerrelais” (one for each axis) but the gyroscopes and relays for the roll and pitch control were removed and replaced with blanking plates. These early units did not yet have the facility to attach a “Dämpfungsregler”.

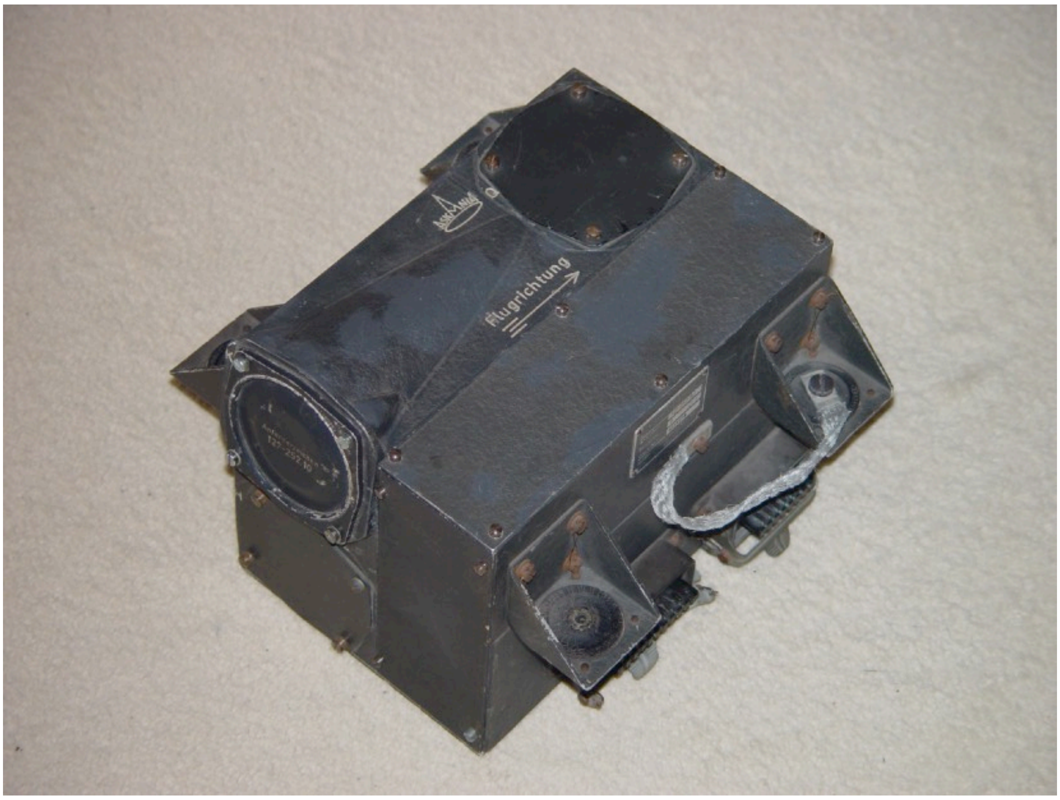

Figure 13: Early type Askania built "Steuerkasten" originally for the PDS system. Note the blanking plates where normally the damping gyroscopes for roll and pitch control would be inserted.

Patin started producing their own SK 11 “Steuerkasten” shortly afterwards, which was a much smaller unit designed for a single gyroscope and steering relay from the outset.

Figure 14: a Patin built SK 11 "Steuerkasten"

The “Dämpfungskreisel” with the “Dämpfungsimpulsrelais” assembly slots into the front panel of the “Steuerkasten” and is secured with four screws. A hinged panel hides four resistors that determine the balance of the “Dämpfung” (damping), “Kurs” (course signal), “Rückopplung” (feedback) and “Vorgabe” (steering bias).

Figure 15: An early Askania "Deampfungskreisel". Note the inspection stamp by Patin

Inside the box, the unit contains two sockets for the “Steuerrelais” and the “Schüttelumformer”. If not used, a special blind plug is inserted instead.

Figure 16: The interior of the SK 11 "Steuerkasten" with the "Deampfungskreisel" and "Steuerrelais" in place. Note the blind plug in socket where the PWU 10 "Schüttelumformer" could be plugged in.

The "Steurkasten" can be placed anywhere in the aircraft, as long as it was aligned along the longitudinal axis of the aircraft. An arrow on top of the box indicates the correct orientation.

The "Dämpfungsregler"

The "Dämpfungsregler" is essentially an air speed indicator, but instead of driving an indicator needle, the diaphragm drives the runner of a potentiomenter. It has two pneumatic connections, one connected to the pitot tube, the other to the static pressure vessel. The "Dämpfungsregler" was typically placed near the air speed indicator and was plumbed in in parallel.

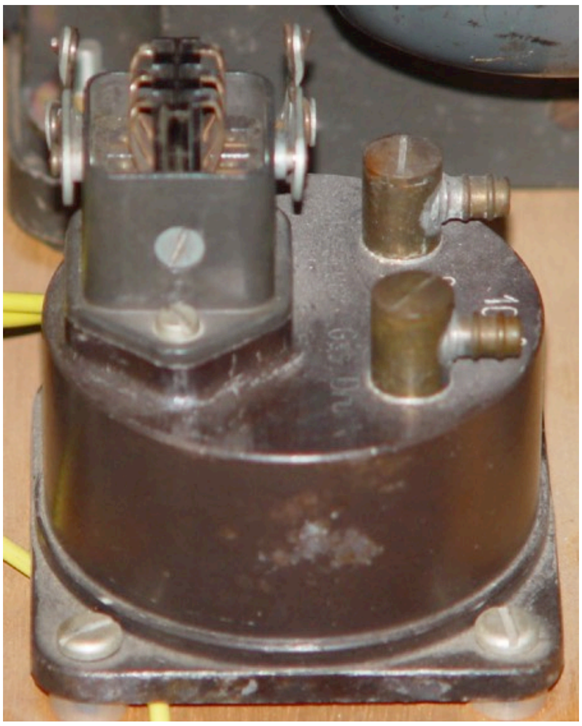

Figure 17: the 'Deampfungsregler"

The “Leonard Umformer”

The “Leonard Umformer” mulitiplies the power supplied from the “Steuerrelais” to power the rudder servo motor. The “Leonard Umformer” consists of an electrical DC motor coupled to a DC generator built on the same axis. The converter is relatively compact unit that can be built anywhere in the aircraft.

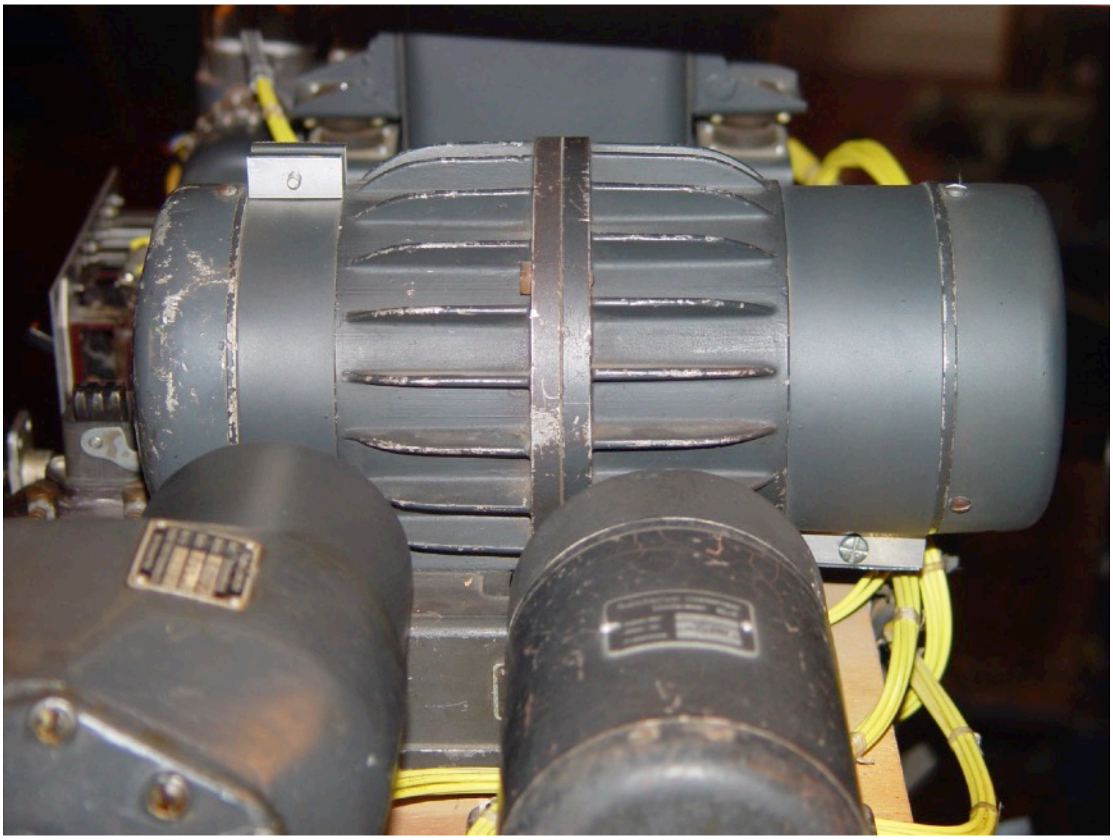

Figure 18: the "Leonard Umformer". Note the cooling ribs moulded onto the housing.

The “Rudergetriebe”

The “Rudergetriebe” used with the PKS11 autopilot is an all electrical rudder servo. A relatively small size electrical motor drives the output lever through a reduction gear and electro-magnetic clutch. The unit is small and light compared to the units used in the K4ü and K12 autopilots and can be mounted in any orientation in a convenient location in the aircraft provided it has the mechanical strength to deal with the torque generated. Both oil filled as well as grease lubricated versions can be encountered, probably to deal with different climatic conditions. Three different lengths of servo output levers could be fitted to deal with different types of aircraft.

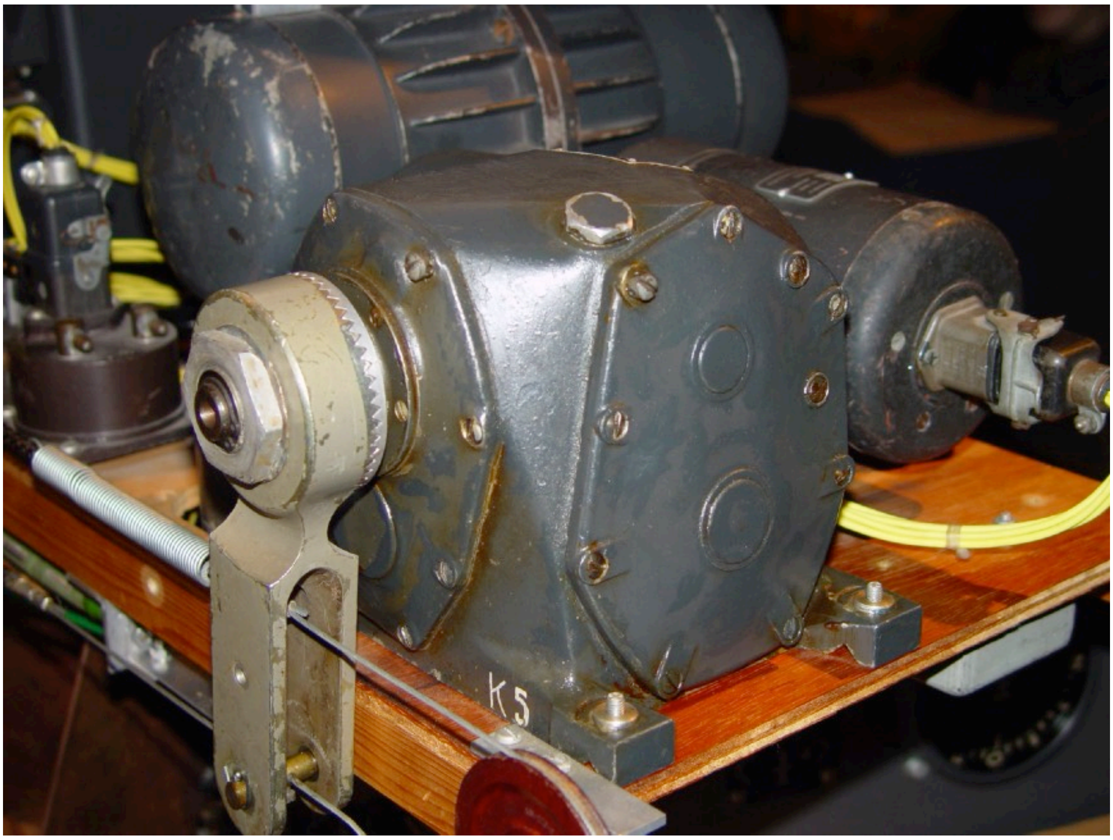

Figure 19: the electrical "Rudergetriebe" for the PKS-11 autopilot. Note the "K5" equipment code painted near the base.

Because the PKS11 provides a “dynamic” control over the rudder movements, rudder movement will only be limited by the aircraft’s reaction in flight, otherwise rudder movement will continue until reaching its mechanical limits. Care must be taken that the mechanical limits of the rudder controls (cables, rods, levers, mounting points etc.) are designed to withstand the full torque of the “Rudergetriebe”

With the “Leonard Umformer” weighing about 6 Kg and the “Rudergetriebe” slightly over 4 Kg the total weight of the Rudder servo drive was just over 10 Kg, another significant weight saving over the LRM 12.

Operating the PKS11 autopilot

Note: During ground tests -unlike with the K4ü and K12 systems- rudder movements will not stop until the mechanical limit of rudder travel is achieved.

During flight preparation, check that the left control knob of the “Kurskreisel” is pushed in and that the “Hauptschalter” is set to “0”. Check that the rudder moves freely. Check that the “Richtungsgeber” on the control column is in the central position and that the “Koppelschalter” is set to “aus”. Check that the “Stützschalter” (typically placed near the bomb aimer’s position) is switched to the “on” position. Check that the rudder is placed in the central position.

Switch on the electrical supply to the PKS11 autopilot and the Patin compass system and switch the “Hauptschalter” to “1”. If the Patin compass is not yet aligned, use the “Richtungsgeber” on the control column to turn the compass to the 12 o’ clock position. Once the Patin compass is aligned, align the top and bottom scales of the “Kurskreisel by turning the left control knob. Check that the “Kurszeiger” functions correctly by moving the left bottom knob slightly left and right. When the two scales of the “Kurskreisel” correspondent, the “Kurszeiger” should be in the central position.

After about two minutes, pull out the left control knob of the “Kurskreisel. The two scales of the “Kurskreisel” should stay synchronised and the “Kurszeiger” should remain centered.

Switch the “Hauptschalter” to “2”. At this stage the rudder should still move freely. Return the rudder to the central position.

Switch the “Koppelschalter” on the steering column to “ein”. The rudder should now be fixed in the central position. Check that by applying maximum force to the rudder pedal, the rudder can be moved slowly. When force is released, the rudder should remain stationary.

By moving the “Richtungsgeber” on the control column left, the rudder should move left and vice versa. Switch the “Richtungsgeber” to one side for about 2 seconds and move it back to its neutral position. The rudder should start moving. When the “Koppelschalter” on the steering column is switched to the “aus” position, the rudder movement should stop and the rudder should move freely. When the “Koppelschalter” is switched back to “ein” the movement of the rudder should continue.

With the “Koppelschatler” still engaged, switch the “Hauptschalter” back to position “1” and check that the rudder can freely be moved. Switch the “Koppelschalter” back to “aus” position”.

The autopilot is now checked and ready to be engaged.

As a last preparation for the flight, use the “Richtungsgeber” to set the heading for the first leg of the flight.

After taxying and take off, the pilot turns the plane towards the desired heading. Once on the heading, switch on the autopilot by turning the “Hauptschalter” to position “2”. The airplane now automatically holds its course. The pilot only has the control the pitch and roll of the aircraft.

Changes to the direction can be made by moving the “Richtungsgeber” to the left or right. For larger course changes, the “Richtungsgeber” can be locked in the 2 degree per second position. The pilot needs to control the roll of the aircraft during the turn by keeping the slip indicator in the “Kurskreisel” centered.

During a bomb run, the control can be taken by the bomb aimer. By moving a slide switch on the “Richtungsgeber” placed near the bomb sight, the autopilot will be controlled by the bomb aimer. An indicator will alert the pilot that the control has been taken by the bomb aimer. In emergencies the pilot’s “Richtunggeber” can overrule the bomb aimer’s control. As long as the pilot’s “Richtungsgeber” is kept in the neutral position, the bomb aimer has control over the course of the aircraft. To avoid unexpected adjustments by the Patin magnetic compass, the “Stützschalter” is switched to the “off” position by the bomb airmer. The course set point is now purely controlled by the gyroscope in the “Kurskreisel” and has no link to the magnetic Patin compass.

The bomb aimer, while peering through the bombsight, can now adjust the aircraft’s course by moving his “Richtungsgeber” left or right. Very small and accurate adjustments can be made.

When the bomb run is complete, the bomb aimer switches the “Stützschalter” back to the “on” position and moves the slider on his “Richtungsgeber” back to the “off” position to give control back to the pilot.

If a malfunction occurs the pilot can disengage the autopilot by pushing in the left control knob on the “Kurskreisel” or flicking the “Koppelschalter” to the “aus” position. Moving the “Hauptschalter” back to the “1” position should have the same effect. If the rudder is still not running freely than the damage is not related to the PKS11 autopilot.

After the flight, push in the left control knob of the “Kurskreisel” and place the “Hauptschalter” in the “0” position. Report any problems encountered during the flight to ground staff.

The PKS11 demonstration rig

In order to demonstrate the PKS11 autopilot, the components need to be mounted on a turntable that can mimic the movements of the aircraft.

Figure 20: Overview of the PKS11 Demonstration rig.

The components of the PKS11 autopilot are significantly lighter so that no counterweights are required when the components are adequately distributed across the turntable. With the instrument cluster on one end, and the “Rudermachine” the other components can be placed to balance the weight.

The principal construction and the drive mechanism for the turntable are identical to the one used on the K4ü, for a description see the equivalent section in the K4ü chapter.

The instruments are placed on a headboard on the far end of the rig, with the electrical controls to the right side and the cable termination block to the left.

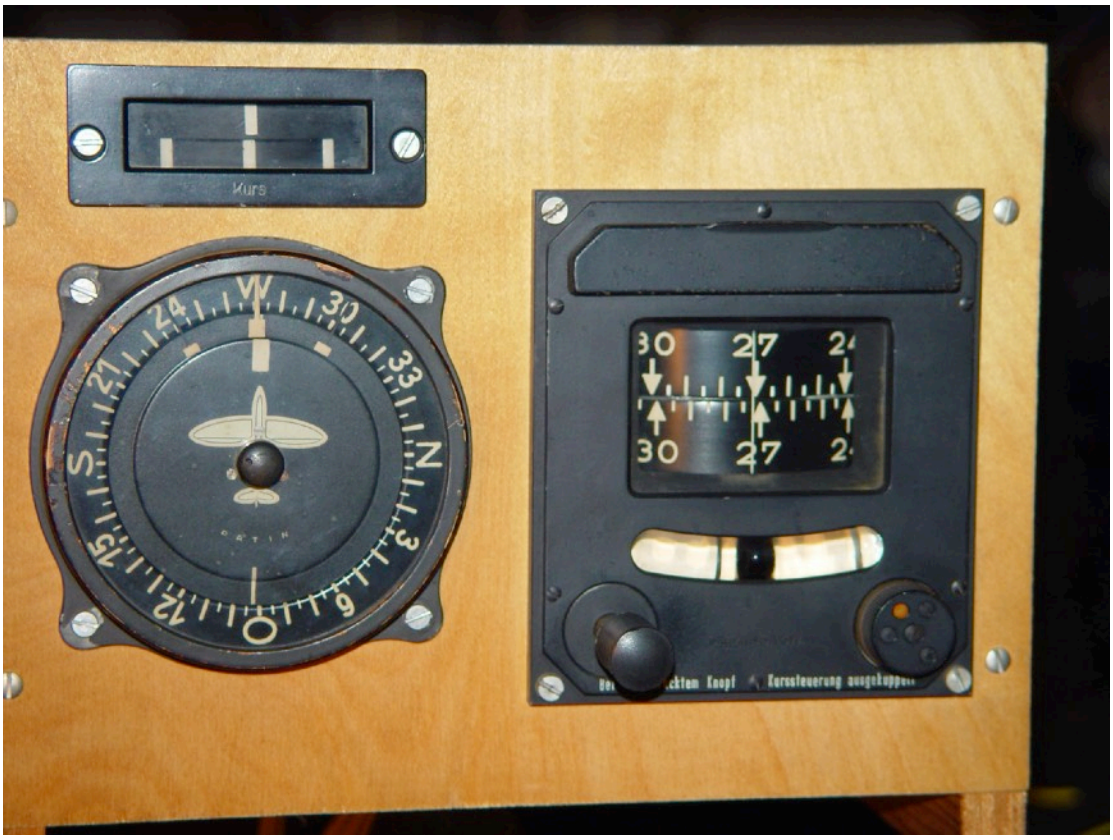

Figure 21: The standard autopilot instrument cluster placed on the far end of the rig.

The “Steuerkasten” has been fitted right behind the instrument panel next to the “Kursmotor”.

Figure 22: The "Steuerkasten" place behind the instruments.

The “Leonard Umformer”, “Drehstrom Umformer”, “Rudergetriebe” and “Dämpfungsregler” have been fitted to the back end of the turntable.

Figure 23: The "Leonard Umformer", "Rudergetriebe", "Drehstrom Umformer" and "Deampfungsregler" on the rear part of the turntable.

Note the cable and chain drive operating the potentiometer of the turntable rotation drive.

Compared to the K4ü and K12 demonstration rigs, the PKS11 rig is more compact and significantly lighter, which gives it a low angular momentum and relatively high resonance frequency.

On the PKS11 demonstration rig, the resistor that inputs to the turntable drive mechanism is connected to the operating lever via a cable and chain drive mechanism. In this way small movements over the “Rudergetriebe” output lever are translated to a larger movement of he potentiometer. A 10-turn potentiometer has been used so that it cannot be mechanically damaged if the rudder motor runs too far.

Again late war style cabling using individual yellow wires has been used in the rig which have been terminated as per original specifications. a thin multicore cables run from the termination block though the headtube to connect to the Lrg 12 “Richtungsgeber”.

Operating the demonstration rig

The rig can be operated as described in the “Operating the PKS11 autopilot” section. As the “Hauptschalter” is moved to the “1” position, the “Drehstrom Umformer” springs to life, and the gyroscopes can be heard running up.

After allowing the gyroscopes to run up and synchronising the “Kurskreisel” the “Hauptschalter” is switched to the “2” position which starts the rather noisy “Leonard Umformer”. The rig is now primed for operation.

If the “Koppelschalter” on the “Richtungsgeber” is switched to the “ein” position, the PKS11 springs to life. After a few movement of the rudder output lever, the rig settles on the set course.

The PKS11 autopilot fitted to the demonstration rig has no “Schüttelumformer” fitted and despite the shaking of the rig by the turntable drive mechanism it suffers slightly from the hysteresis problem. The rig oscillates slightly from side to side a few tenths of a degree with a frequency of about once per 3 seconds. Only by tuning the damping factor to a relatively low setting can this oscillation be stopped but as a result the damping is under-critical.

If the rig is disturbed by hand, the “Rudergetriebe” can be seen to respond immediately. The addition of the acceleration signal in the “Dämpfungskreisel” causes a harsher reaction to disturbances in the PKS11 autopilot than in the other two autopilots. Because of the under-critical settings of the system, it overshoots and takes five or six swings for the rig to return to the set course. The rig can be tuned to reduce these swings, but than the oscillation caused by the hysteresis is introduced.

Overall the PKS11 responds faster and more nervously to disturbances than the K4ü and even the K12. It is clear that the system is adaptable to a wide range of aircraft, including the to those with a much lower angular momentum and higher speed such fighters.

To turn the rig, the “Richtungsgeber” is engaged and the “Kursmotor” starts turning the set course on the instruments. The signal of the “Richtungsgeber” is also fed to a winding on the “Steuerrelais”. This signal is called the “Vorgabe” or bias and it overcomes the tendency of the damping gyroscope to keep the system static. As soon as the “Richtungsgeber” is engaged, the “Rudergetriebe” gives a steering pulse to the rudder, which starts the rotation of the rig. The damping gyro will now keep the rate of turn constant as long as the “Richtungsgeber” is engaged. If the resistors in the “Wiederstandkasten” are properly adjusted, the rig should turn at the same speed as the adjustment of the setpoint by the “Kursmotor”. This can be verified by observing the “Kurszeiger”, as it should stay more or less centered during the turn. As the “Richtungsgeber” is released, a pulse of counter rudder is given to arrest the rotation.

With the “Stützschalter” switchted on, the effect of the Patin “Führertochterkompass” PFK/f3 on the Kurskreisel can be demonstrated. This effect is called “Überwaching” or overseeing of the directional gyroscope. First, the gyroscope is brought out of alignment by momentarily pushing in the left knob on the “Kurskreisel” and turning the rig by hand 5 degrees or so from the setpoint (the autopilot will not react to this disturbance as pushing in the knob disengages the autopilot). When the knob is pulled back out, the autopilot will react by aligning the (now slightly offset) bottom scale with the fixed top scale of the “Kurskreisel”. The “Kurskreisel” and the “Kurszeiger” will now look fully aligned, but the Patin “Führertochterkompass” is showing a course about 5 degrees from the 12 o’clock position. The output resistor in the “Führertochterkompass” will now give a small signal to the “Kurskreisel”, turning the bottom scale at about one degree per minute. Since the autopilot is however keeping the bottom and top scale of the “Kurskreisel” aligned, the only movement spotted will be a very slow turning of the rig and a very slow return of the Patin “Führertochterkompass” towards the 12 o’clock position.

By switching the “Koppelschalter” to the “aus” position, the “Rudergetriebe” is instantaneously disengaged, leaving the rudder to be moved by hand.

When the “Hauptschalter” is switched back to the “1” position, the “Leonard Umformer” runs down while the “Drehstrom Umformer” keeps running powering the gyroscopes.

After switching off the autopilot by turning the “Hauptschalter” back to the “0” position, the “Drehstrom Umformer” and the gyroscopes start running down. For the first 30 seconds or so, the gyroscopes contain enough energy to power the “Drehstrom Umformer” in reverse. Once the “Drehstrom Umformer” has stopped, the gyroscopes will run out for another 10 minutes or so.

Now all switches and controls can be reset and the rig put in it’s parking position, ready to fly the next “mission”.