The Patin remote compass system of the German Luftwaffe

Introduction and history

For most of their early existence, aircraft had used magnetic compasses mounted in or near the instrument panel to find their bearing. In the 1930’s the number of electrically powered instruments and systems and the proximity of magnetic materials contained in engines and weaponry was increasingly having an effect on the accuracy of magnetic compasses mounted in the cockpit.

A remote reading compass was needed that could be placed in a part of the aircraft free of the influence of electrical currents and steel structures and which provides a remote read out in the cockpit. The challenge was to take a near frictionless reading of the compass needle and transfer this to a signal that could influence a remote reader.

One of the first to come up with a solution was the firm of Karl Bamberg in 1917. Bamberg used a system of two light beams falling on two light sensitive Selenium cells. An eccentric disk coupled to the magnetic needle turned between the two beams covering one more than the other as the disk turns away from the central position. With the two Selenium cells placed in the bridge circuit, the resulting electrical signal is proportional to the deviation from the central position. This system gives a reading of course differential rather than actual course. To find the actual course, the housing of the compass has to be turned until the differential reads zero. A set point indicator and a left-right indicator would be placed on the instrument panel. The set-point indicator would be linked by a mechanical drive to the remote compass housing placed in the hull of the aircraft. To find the flown course, the pilot would adjust the set point indicator until the left-right indicator reads zero. Although a sound principle, it proved difficult the manufacture reliable and consistent Selenium cells at that time, and the early photoelectric “differential compass” continued to be plagued by reliability problems.

Askania used the basic principle of the “differential compass” for the development of their “Fernkompass” in 1927. Rather than using two light beams, the Askania used two pneumatic jets interrupted by an eccentric disk. Askania’s pneumatic Lfk 9 “Fernkompass” (discussed in more detail in the section on the Askania Lz12 autopilot) came in relatively widespread use with the fledgling Luftwaffe. Siemens also developed a remote compass along the “differential compass” principle, this time using electrodes introducing an alternating current through an electrolyte fluid. A shaped disk between the electrodes would disturb the current flow through the electrolyte. By rectifying the current trough the electrode pairs a differential reading could be obtained.

Although the Siemens system provided a reliable electrical signal, it could not get away from the disadvantage that it could only show a course differential. The search continued for a remote indication systems (also called synchronization system) that could mimic the rotation of a real magnetic compass. In the 1920's and 30's several electronic synchro systems were patented, using names like Dynasyn, Selsyn, Desyn, Magnesyn etc. The challenge was to transmit a very small torque (as generated by a compass needle) using the 27 V DC power supply with sufficient accuracy.

In the early 1930’s the Patin company had developed an industrial synchro system by combining the principle of a Desyn and potentiometer synchro. By 1936 the Patin system was successfully applied to a remote compass system, which could accurately show the actual rotation of a magnetic compass in a remote location. In 1938 the German Luftwaffe adopted the Patin system as the standard compass system for all their aircraft, which it remained throughout the war.

Worth mentioning is the invention in 1937 of magnetometer system by Friedrich Förster. By standardizing on the electro-mechanical Patin system, the German aircraft industry did not benefit much from the invention of the “Förster-Sonde”, better known as the flux-gate which underpins most modern magnetic compass systems. The invention was not lost on the American Bendix corporation, who applied it in their gyro-fluxgate-compass used in the heavy B-17 and B-24 bombers towards the end of the war.

Figure 1: A Patin PFK/f2 compass repeater fitted to a Messerschimtt Bf109 G-6 panel

Description and operating principles

The Patin “Fernkompaß” uses a synchro system to transmit the position of the magnetic needle in the “Mutterkompaß” master to a rotating indicator in the “Tochterkompaß” repeater compass.

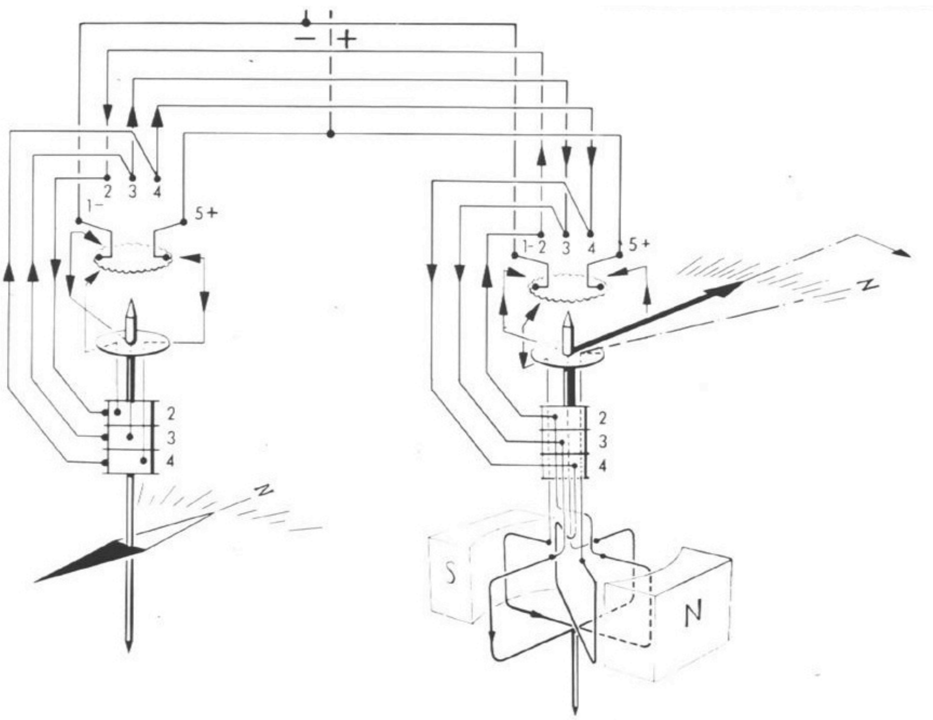

Figure 2: the synchro system in the Patin remote compass

A finely wound toroid shape potentiometer is mounted in the top of the compass. Three very fine runners connected to the compass rotor run around the circumference of the potentiometer at 120° distance. The runners are connected to sets of collectors and very fine contact wires to transfer the voltages from the rotor to the static housing. A 27 Volt DC supply voltage is applied across the potentiometer, connected at points 180° apart (V1 and V5). Dependent on the position of the compass needle, the three runners will see three different voltages: V2, V3 and V4.

The receiving instruments contains a similar circuit, which will produce another set of voltages: V2’, V3’ and V4’. If the transmitter and receiver are in the same position the three sets of voltages will be equal: V2 = V2’; V3 = V3’ and V4 = V4’. The three sets of voltage differentials are fed to a set of rotor windings set 120° apart turning in a permanent magnetic field. If the transmitter and receiver are not in the same position, these rotor windings will generate a torque, which will turn the instrument until the voltage differentials are zero and thus the receiver is exactly aligned with the transmitter.

In order to reduce friction the runners and contact wires have to be extremely thin; also the potentiometers also have to be extremely finely wound. The wires connecting the runners to the rotor windings in the repeater instrument are extremely thin and were covered in a lactose based insulator. Over time in combination with moisture this insulation can produce lactic acid which corrodes the thin wires. unfortunately this corrosion mechanism has destroyed functionality of a large proportion of surviving Patin indicators over the decades. To prevent further degradation it is essential that these instruments are kept in a dry and temperate environment.

The Patin “Fernkompaß” consists of two main components:

- a PFK-m “Mutterkompaß” master compass
- a PFK-f or -b “Tochterkompaß” compass repeater

with PFK standing for "**Patin** Fern Kompass"

- The PFK-m “Mutterkompaß” master compass

Figure 3: PMK/m "Mutterkompaß" master compass

The master compass contains the actual magnetic compass, suspended in an petroleum filled bowl to dampen the swinging. The movement of the compass needle is transferred to a synchro transmitter fitted to the top section of the master compass.

Note the warning shield next to the connector, this warns to use a non-magnetic contact plate in the connector.

A magnetic compensator is held above the compass housing by three arms. Insertion of small magnetic needles allows the compass to be compensated for magnetic deviations caused by ferrous metal parts in the aircraft.

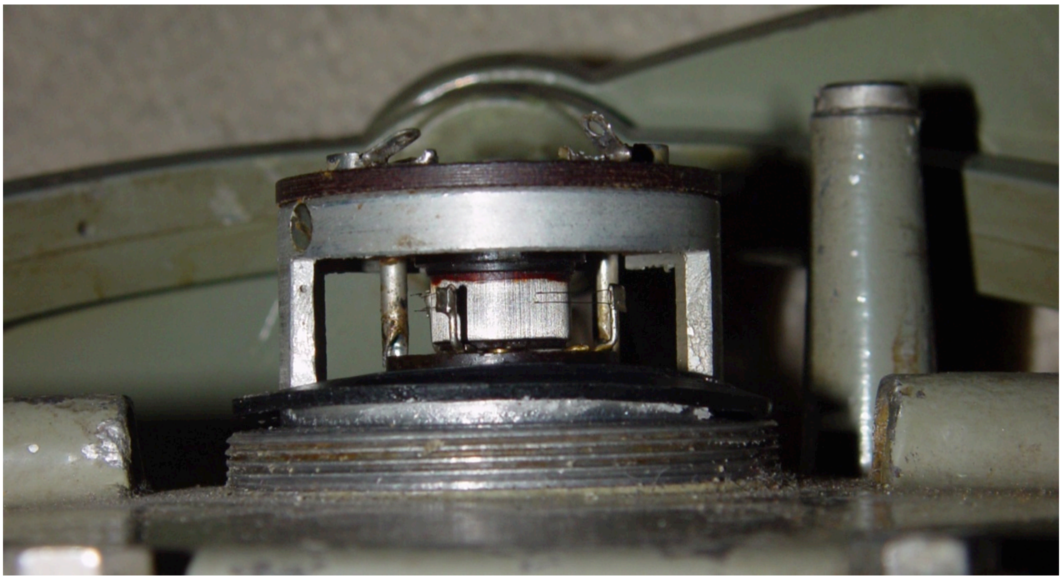

Figure 4: transmitter potentiometer in the Patin master compass

The transmitter potentiometer is fixed to the top of the housing while the three runners connected to the rotating float turn around the potentiometer. Note the extreme fineness of the contacts, a typical construction feature of Patin equipment. The top-section containing the transmitter circuit would be hermetically sealed and is part of the petroleum filled bowl. Note that the filling spout on the right is higher than the potentiometer compartment. The compass must be tilted so that no air bubbles are left in the potentiometer compartment after filling with liquid.

Figure 5: PMK-m date plate, note that it is alternatively denoted “KM-1” (Kompass Mutter 1)

- The PFK-f or -b “Tochterkompaß” compass repeater

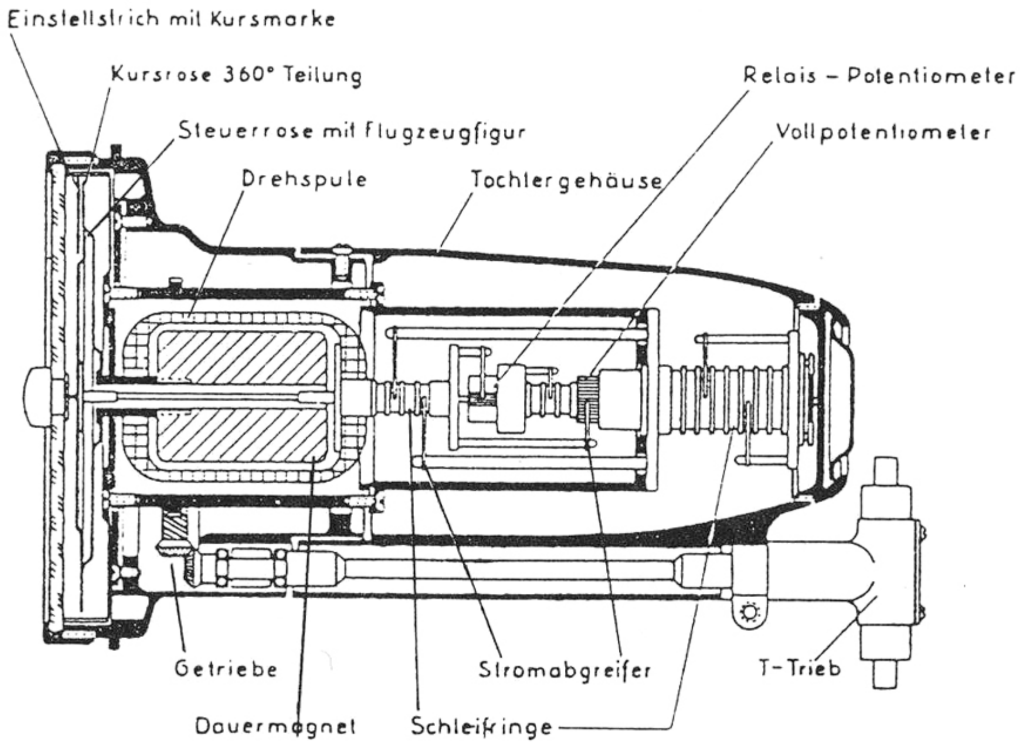

Figure 6: Cross section through a Patin PFK-f3 compass repeater

All Patin compass repeaters contain the synchro system with the potentiometer and the rotor windings. The cross section in figure two shows how a typical instrument is configured. The potentiometer (Vollpotentiometer) and the rotor windings (Drehspule) as well as the contact wires (Schleifringe) can clearly be recognized. The whole repeater assembly can be rotated in the housing so that a pre-set course can be turned to the 12 o’clock position. If the indicator disk (Steuerrose mit flugzeugfigur) is also pointing at the 12 o’clock postion, the aircraft is flying towards the pre-set course. All the pilot has to concentrate on is to keep the indicator pointing to the 12 o’clock position. Another extra feature unique to the PFK/f3 type is the “Relais Potentiometer”. This potentiometer measures the differential between the pre-set and the flown course and generates an electrical signal if the indicator is not pointing at the 12 o’clock position.

The Patin compass repeater subtypes

A number of different repeaters were manufactured, the type code typically starts with PFK (Patin Fern Kompass) followed by a letter and a number denoting the subtype. Most subtypes are of the “f” type, which standards for (Flugzeug)führer, the German term for Pilot (and not the sinister man with the little moustache). All aircraft would have had one of the “f” type repeaters mounted in the Pilot’s line of sight. In larger aircraft a second repeater of the “b” type could be fitted, with “b” standing for Beobachter or observer/co-pilot. Special indicator types for use with radio direction finders completed the range of compass types.

PFK-f1: a "Führertochterkompass" type 1. Standard 11cm diameter instrument. The pre-set course of the type 1 can be adjusted either manually by turning the knurled bezel or by course motor.

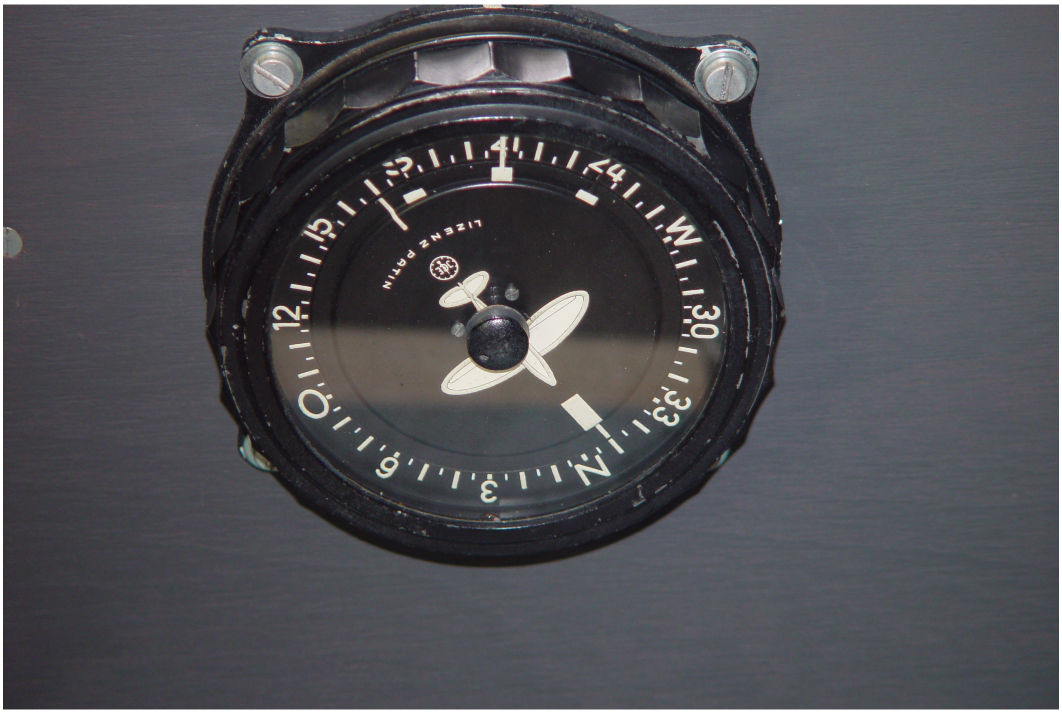

Figure 7: PFK/f1 repeater compass. The instrument has a knurled bezel that can be rotated to change the set point manually. Alternatively it can be connect to a course motor.

PFK-f2: a "Führertochterkompass" type 2. This was a smaller 8 cm diameter version fitted to many fighter aircraft later in the war. Again the pre-set course adjustment could be made manually or by a course motor.

Figure 8: PFK/f2 repeater compass is a small diameter version of the f1. Note the knurled bevel for manually adjusting the set-point and the late-war "open" aircraft symbol of the indicator

PFK-f3: a "Führertochterkompass" type 3. A 11 cm diameter instrument fitted with a output resistor for an autopilot. The pre-set course could only be adjusted by motor so there is no knurled bezel for manual adjustment.

Figure 9: PFK-34 compass repeater. There is no knurled bezel for manual adjustment. The instrument has two connector sockets on the side of the housing.

PFK-f4: a "Führertochterkompass" type 4. Also 11cm diameter, this compass contained a potentiometer and a small motor that could automatically adjust the compass ring to 12 o'clock position. This version was developed specifically for use with the PKZ/13 and PKZ/14 "Kurszentrale".

Figure 10: PFK-f4 compass repeater. Note the electric motor mounted under the instrument housing

PFK-f6: a "Führertochterkompass" type 6. An 8 cm diameter version of the f3 with output resistor. Probably prototype only as no surviving examples have been encountered.

PFK-f7: a "Führertochterkompass" type 7. An 8 cm diameter version of the f4 with automatic setpoint adjustment. Probably prototype only as no surviving examples have been encountered.

PFK-f8: a "Führertochterkompass type 8. A "shallow" version of the 8cm diameter compass requiring less space behind the instrument panel of the aircraft developed for late war fighter aircraft.

PFK-b1: a "Beobachtertochterkompass" type 1. An 11 cm diameter instrument Identical to the 11 PFK/f1 for use in larger aircraft as a secondary instrument. Typically a f1 or f3 would be fitted on the left side of the instrument panel for the pilot with a b1 fitted to the right side of the panel in front of the co-pilot. The pre-set course of this type could be adjusted either manually or by motor.

PFK-b3: a "Beobachtertochterkompass" type 3. An 11cm diameter instrument similar to the PFK/f3 but lacking the output resistor. Similarly this was used in larger aircraft with the f3 fitted for the pilot and the b3 for the co-pilot. The pre-set course of this type could only be adjusted by motor.

PFK-p: a "Peilrtochterkompass". a 15cm diameter version for use in the PFA/R radio compass indicator (total diameter 20 cm). The PFK/p could rotate within the larger PFA/R housing by mechanical means providing an indication of the flow course and the direction of the detected radio signal at the same time.

Figure 11: A complete PFA/R radio compass indicator. The central instrument is the PFK/p repeater compass.

PKT-p2: “Peiltochterkompaß. A 15cm diameter all electrical version of the PFA/R, the direction of the detected radio signal is electrically transmitted to a small motor similar to the one fitted in the PFK/f4. Like with the PFA/R the flown course and the direction of the detected radio signal are indicated at the same time.

Figure 12: The PKT-p2 radio compass indicator.

Operating the Patin Fernkompaß

Before flight

To switch on the Patin remote compass system, push the relevant electrical pushbutton. The instrument will immediately swing and display the correct heading. Adjust the set-point of the instrument onto the desired course, in single-seater aircraft this is typically done by manually turning the knurled bezel of the instrument. In larger aircraft fitted with an autopilot the set-point is changed by moving the thumb switch on the control column left or right.

Beware that the instrument displays the magnetic north. Pilots should be trained to calculate the true north and should be provided with valid magnetic declination tables for their area of operation.

Due the friction of the various contacts in the Patin system, it operates best when the instrument and master compass are subject to engine vibration. If the aircraft is at rest the instrument may have to be tapped slightly to get an accurate reading.

During flight

To fly the set course, align the aircraft symbol on the instrument to the 12 o'clock position. When slow turns are made of about 3° per second, the compass will turn smoothly without much swinging. When fast turns are made, the compass will lag and swing and may take up to 10 seconds to accurately display the new heading. During acrobatic flying, the pilot should not rely on the displayed course, using visual cues of the sun and ground instead. Even though acrobatic flying may unsettle the compass, flying straight for about 10 seconds will automatically settle the compass and a reliable reading can be taken.

To change course, re-adjust the set-point by turning the bezel or using the thumb switch to activate the course motor. Turn the aircraft towards the new heading. When flying an aircraft with the autopilot engaged, changing the set-point with the thumb switch will automatically cause the aircraft to turn in sync with the instrument so that the aircraft symbol will stay aligned with the 12 o'clock position.

After flight

Switch off the electrical supply to the compass system. Report any faults to the ground crew. As no adjustments or repairs can be made, faulty components will require replacement. After replacing the master compass, the aircraft should be "swung" to adjust the compensation of the master compass. In this procedure, the aircraft is placed on a cradle (located in a position free of magnetic interference) and rotated through 360°, taking uncompensated compass readings every 5°. A deviation table is created which allows the placement and strength of the compensation magnets to be calculated. With the compensation magnets in place, repeat the "swing" procedure.

