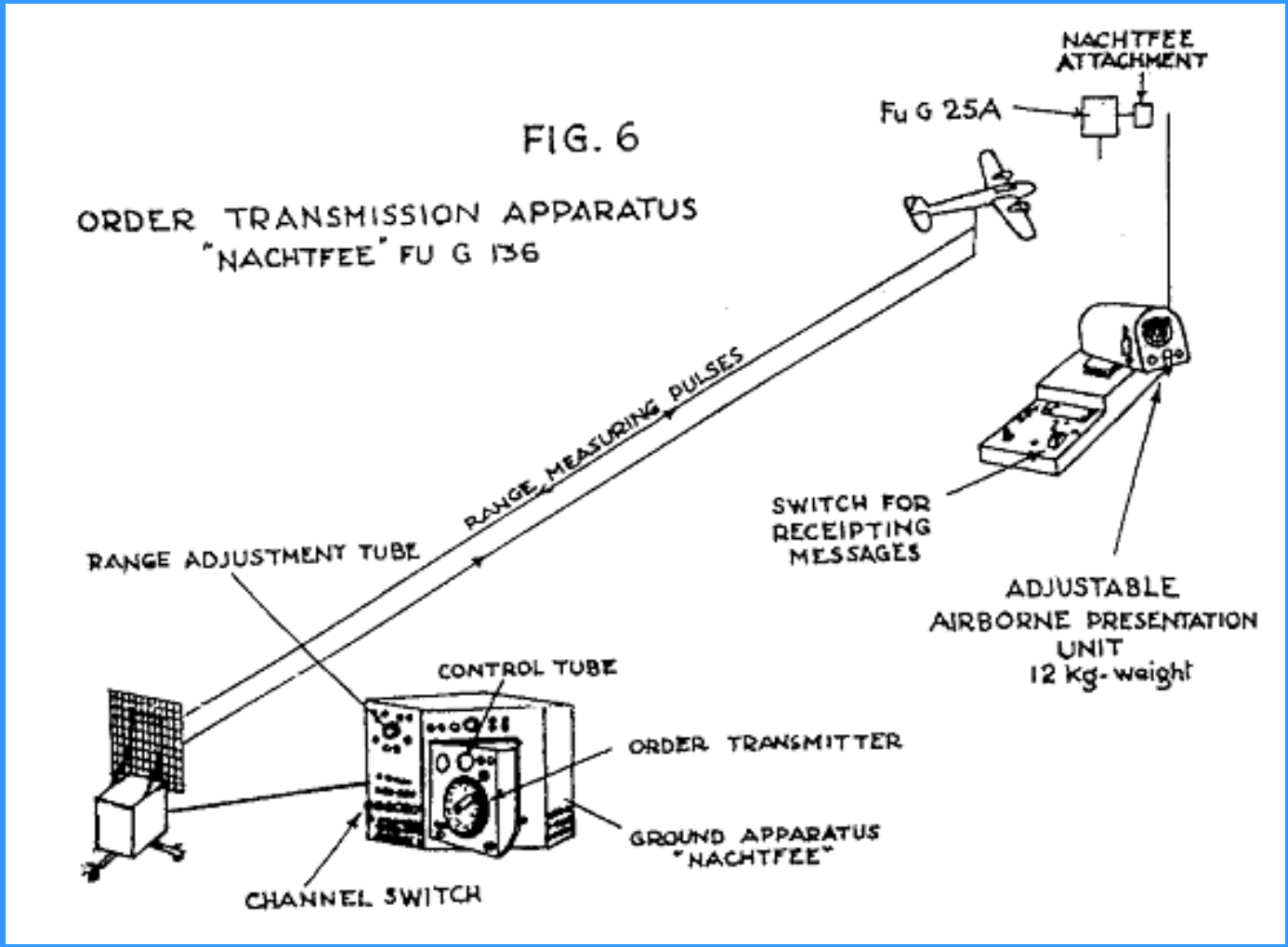
How Nachtfee worked

explaining its fundamentals

a bit

differently

By Arthur O. Bauer



Finding this drawing forms the nucleus of our Nachtfee survey

Nachtfee
A navigational aid

- Its main aim was to guide an aircraft without additional communication, and bringing it over a designated target, like Oboe did

- Using the already existing EGON IFF system

- Without very special means it is impossible to distinguish what the information is about

- Jamming is possible, but cannot change the content of its message

System disadvantages

- The requirement for mutual time-base stability were too high ($>10^{-7}$) in respect to 1940 quartz techniques for military applications

- Additionally, an extra crew member should watch the ‘order’ display

On what fundamental principle relied Nachtfee?

It is all about signal phase in the domain of time
but
why and how?

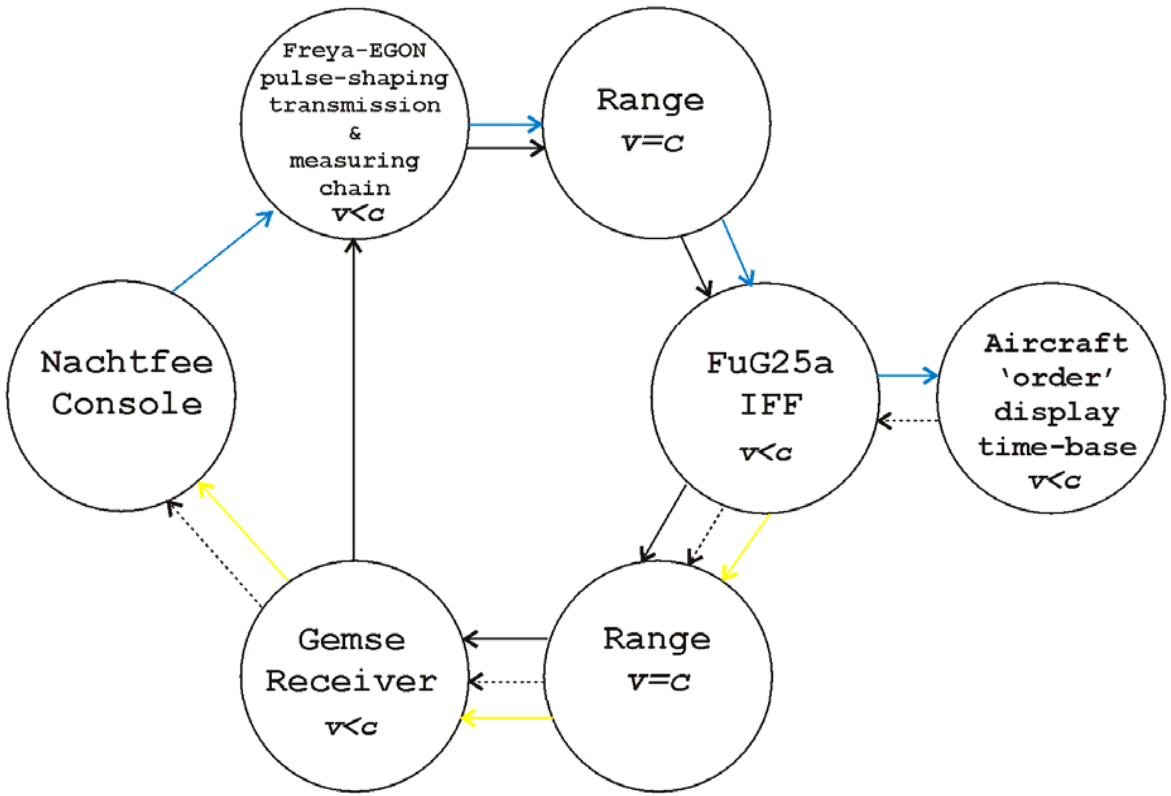
Nachtfee's creator may be regarded Dipl.-ing. T. von Hauteville (Rechlin) who also created the so-called Y-system; based upon measuring and comparing both the Y-ground-signal-phase with the returning measuring-tone-phase originating from a controlled aircraft. The FuG16ZY system was known in Britain as Benito. This system allowed pilots to get their actual map position, without the need of navigating themselves.

As to get an idea on which principle Nachtfee is relying I would like to use an analogy

Please imagine viewing a film strip, where someone adds or removes a few frames. Viewing such a film you hardly will notice that something have been manipulated.

Proving that something has happened is possible by means of comparing to a second equal film which is not changed.
Viewing both films simultaneously will indicate the instant where the situation changes; as well as to what extend.

Please imagine the manipulated film constituting the Nachtfee system data.
Whereas the genuine film representing the non effected aircraft time base.

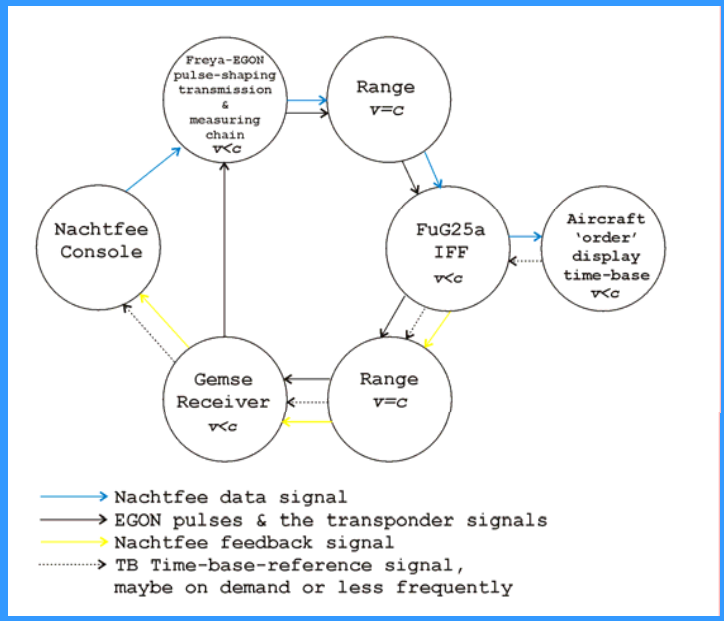

Freya-EGON
pulse-shaping
transmission
&
measuring
chain
v<c
Range
v=c
Nachtfee
Console
FuG25a
IFF
v<c
Aircraft
'order'
display
time-base
v<c
Gemse
Receiver
v<c
Range
v=c
Nachtfee data signal
EGON pulses & the transponder signals
Nachtfee feedback signal
TB Time-base-reference signal,
maybe on demand or less frequently

Nachtfee constituted a closed loop

Nachtfee was an integral part of a Freya-EGON site, also known as EGON-B (B likely stood for Befehl or ‘order’). Freya-EGON was directed such that its stationary beam crossed the target area.

After the to be guided aircraft became airborne it had to follow the guiding EGON-signal-path, getting operational information via Nachtfee.

The advantage of EGON is that its operational distance exceeds regular Freya radar range. Normally radar signals have to bounce at the metal surface of a platform though, the signal-strengths is decreasing with the 4^{th} power versus distance. Whilst, EGON is a secondary radar signal, which is to be received by the FuG25a IFF transponder, being within it received, amplified and retransmitted towards the station of origin. Freya’s range may have been say 100 km, whereas the EGON operational range was about 250 km.
The range limit was mainly owing to the fact that EGON, like Nachtfee, operated with a PRF of 500 Hz which equals λ = 600 km. In radar terms 300 km, as distance is bridged twice!



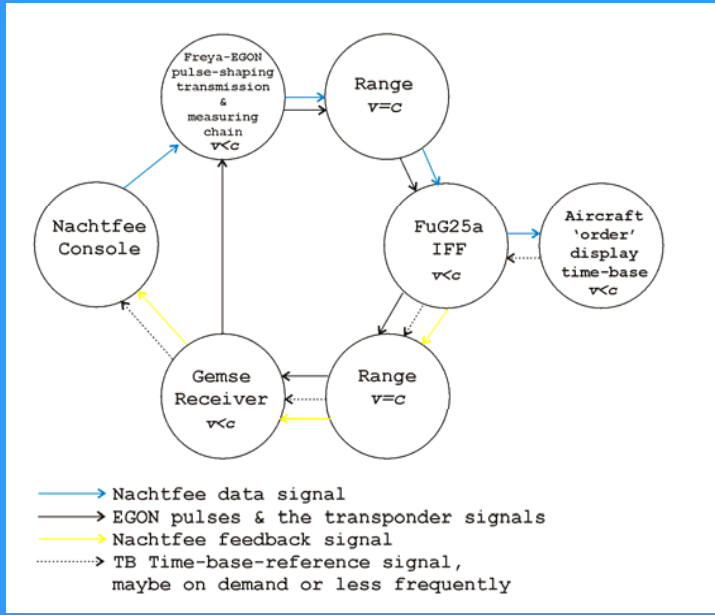
The Nachtfee system consisted of two feedback loops

The Nachtfee ‘order’ data is fed onto the EGON transmitter and being radiated

Crossing the space of its actual range

Passing through the FuG25a IFF transponder, the Nachtfee ‘order’ signal fed onto the aircraft display as well

Retransmitted EGON and Nachtfee signals passing equal range after reception by the Gemse RX returning at the Nachtfee feedback control screen LB2

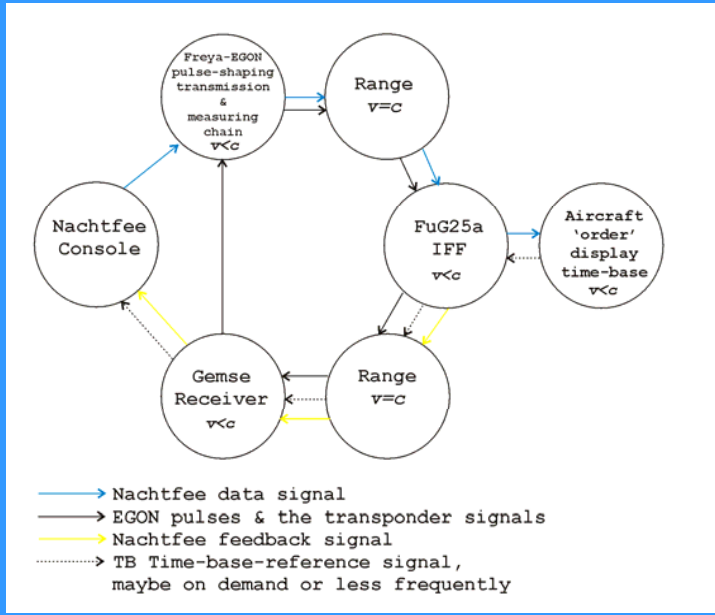


The second system loop is just the other way around

In some way or another, the aircraft time-base-phase TB is combined with the retransmission carrier, crossing range, passing Gemse, and being made also visible on the LB2 control screen

On the LB2 screen we get two kinds of signals: Nachtfee feedback (coherent) as well as the TB reference signal pulse or blip

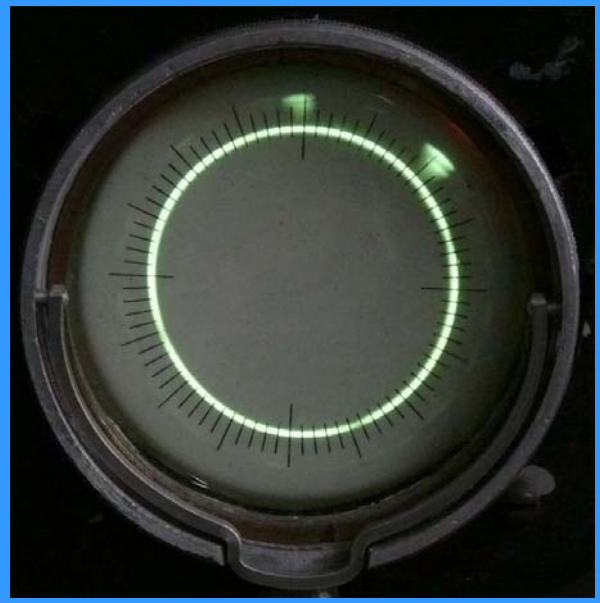
The TB pulse gets a certain vector off-set (error correction) which *crucially provides a data-phase off-set for the next Nachtfee signal pulse*!

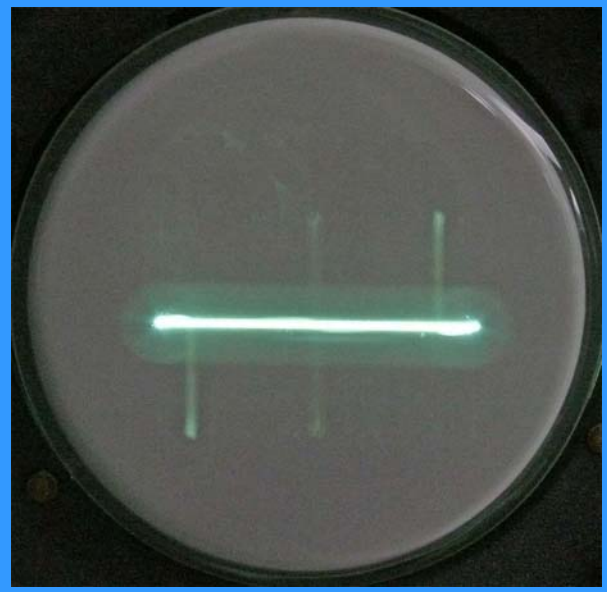


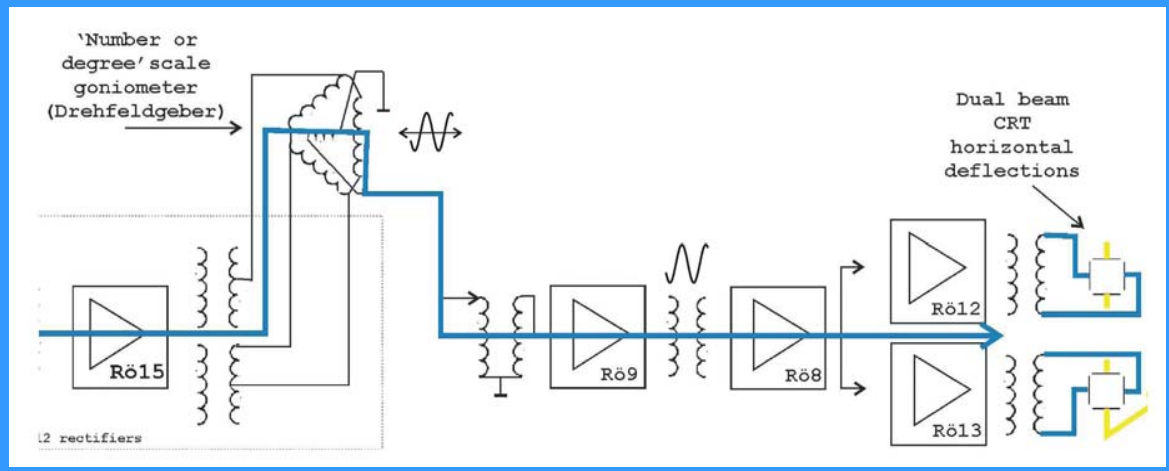
The Nachtfee data pulse has got a data or ‘order’ phase off-set in such a way that it will arrive at the aircraft display in accordance to the actual Nachtfee compass pointer.

The reason for this, is the fact that the aircraft time-base will most likely having a different signal-phase than the one on the ground.

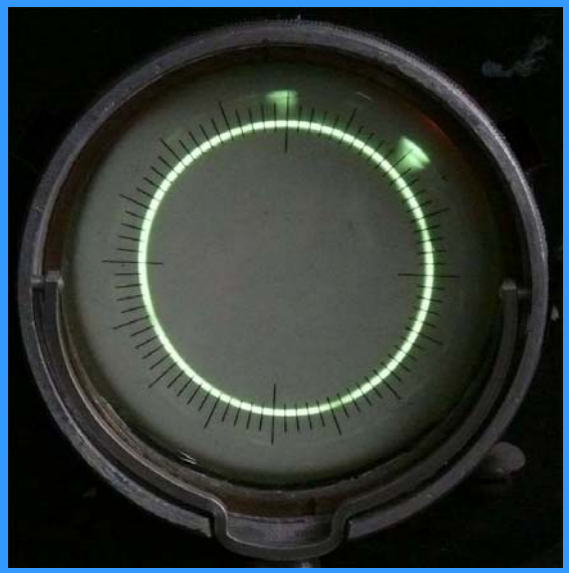
The deviation is visible on the LB2 control screen. When we take into account the given system parameters it is possible to manipulate the actual Nachtfee data phase such that it counters these errors.

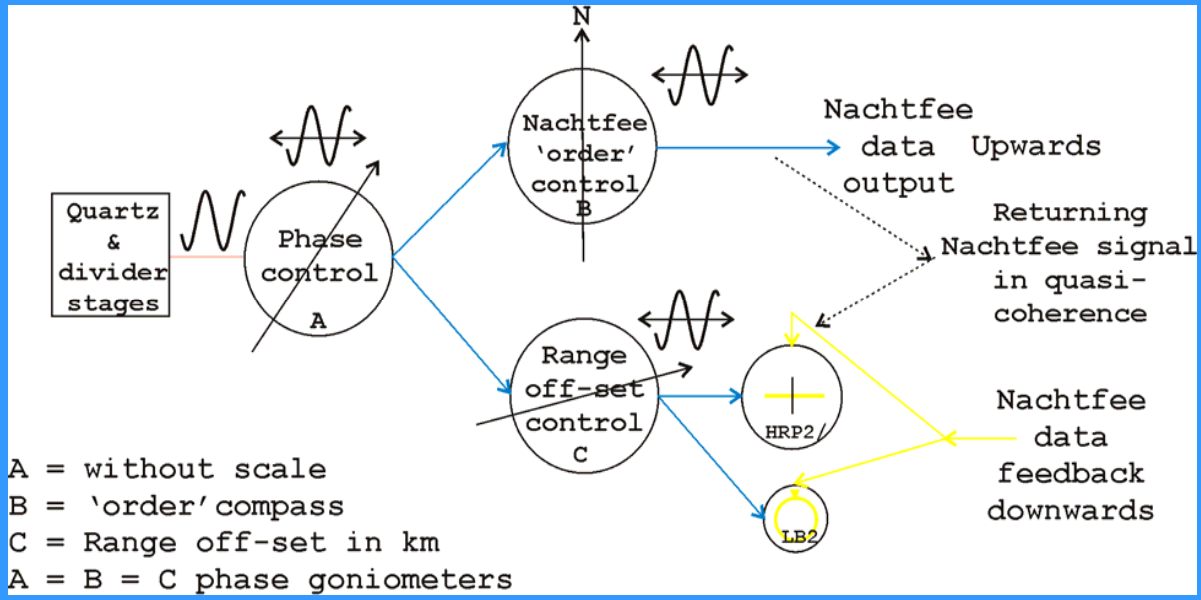






Due north on the left is the Nachtfee feedback pulse adjusted back-to-back in the centre of the dual trace CRT correctly; by means of the number or ‘Range off-set’ control. Using the goniometer on the left-hand side



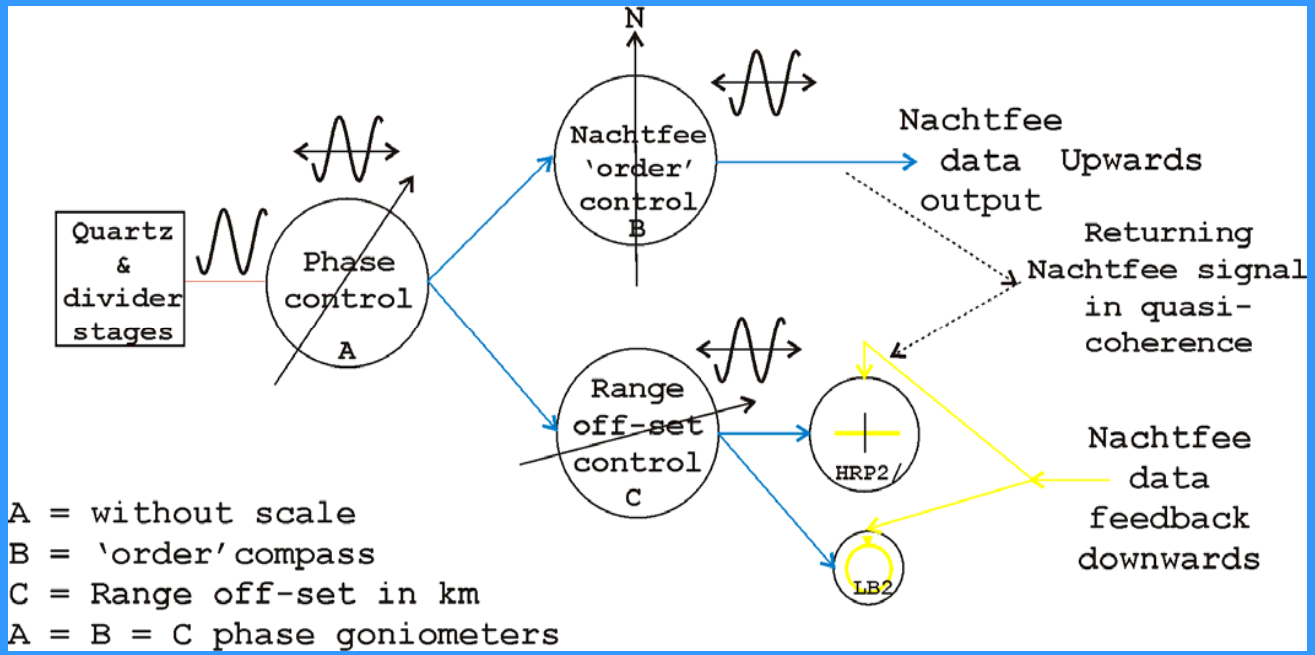


Firstly, the pulse due North is correctly adjusted by means of goniometer C

The pulse or blip at about 45° represents the TB reference pulse in respect to its phase-difference versus the own Nachtfee time-base-phase

I regard that such phase difference is having a system value and that this value can be compensated for

Operating the general ‘Phase’ goniometer A, (without effecting Range off-set) such that the TB pulse gets a vector pointing ≈ 45° (in our case)

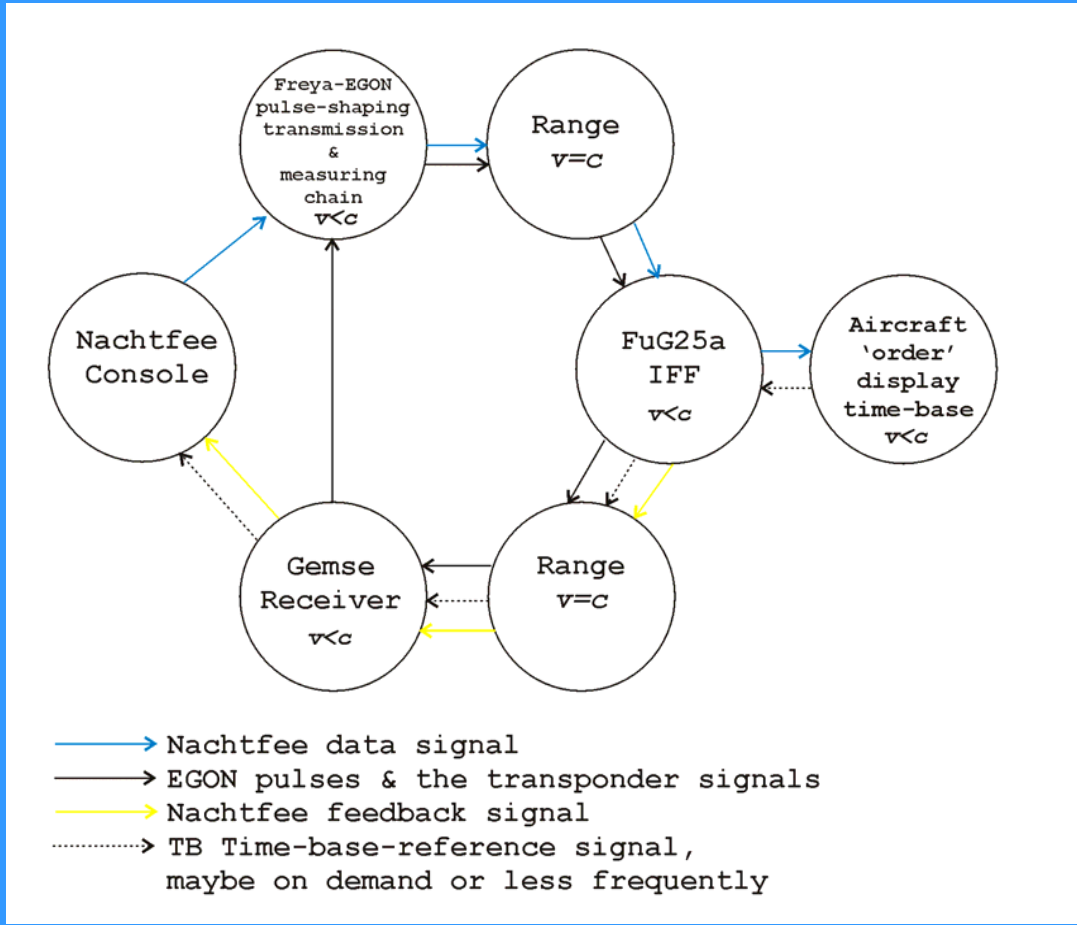


Goniometer control B is the actual ‘order’ or command compass

It effects only the signal phase of the Nachtfee data-output

When this control is being operated, Nachtfee ‘order’ is generated causing a virtual vector rotation of the blip on the Nachtfee control screen (LB2) as well as at the aircraft ‘order’ CRT screen

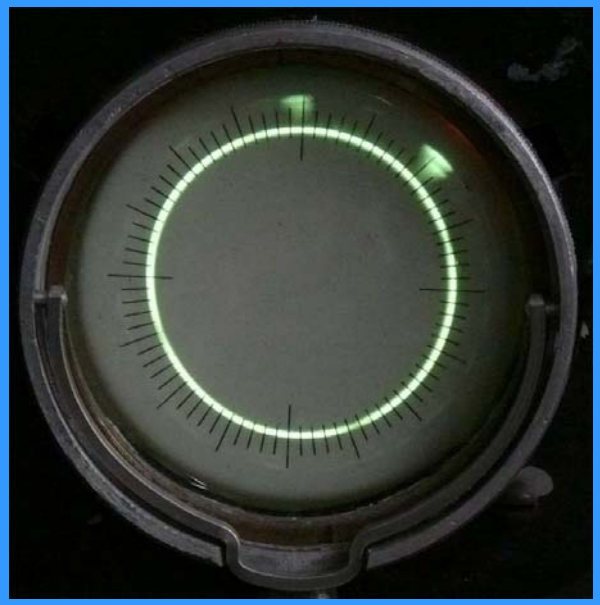
Though, how is ascertained that the ‘order’ blip appears correctly?

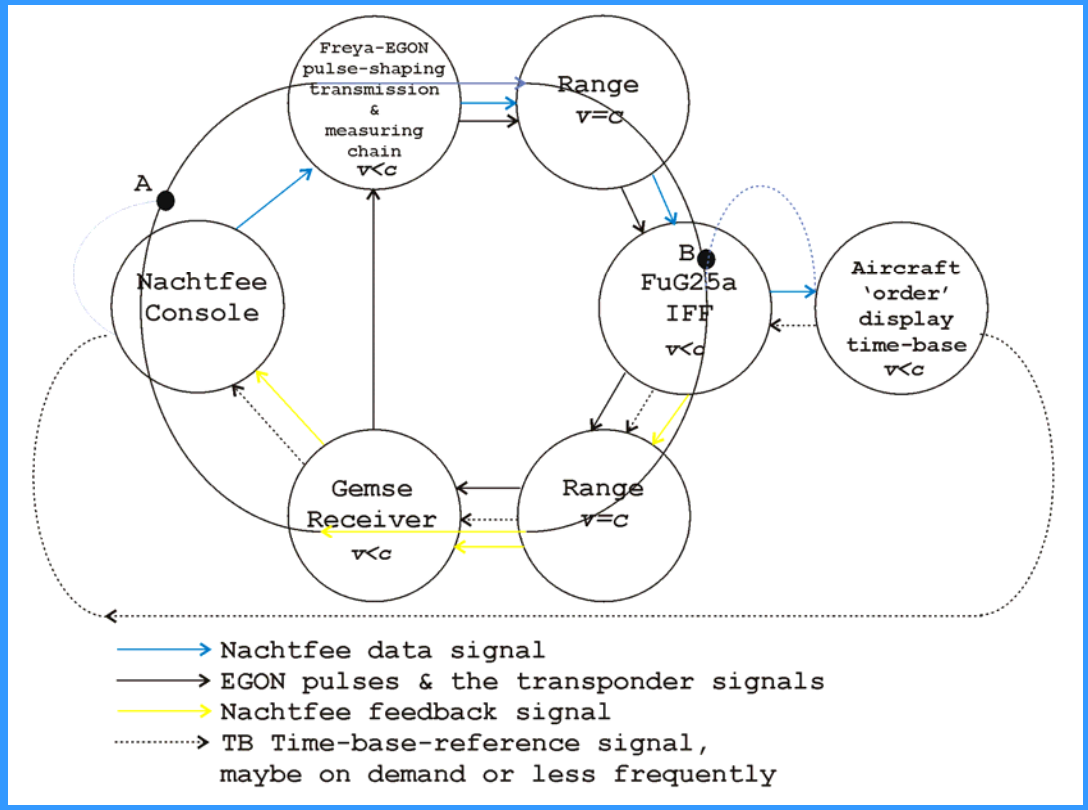


Shown is the loop or feedback principle of the Nachtfee system

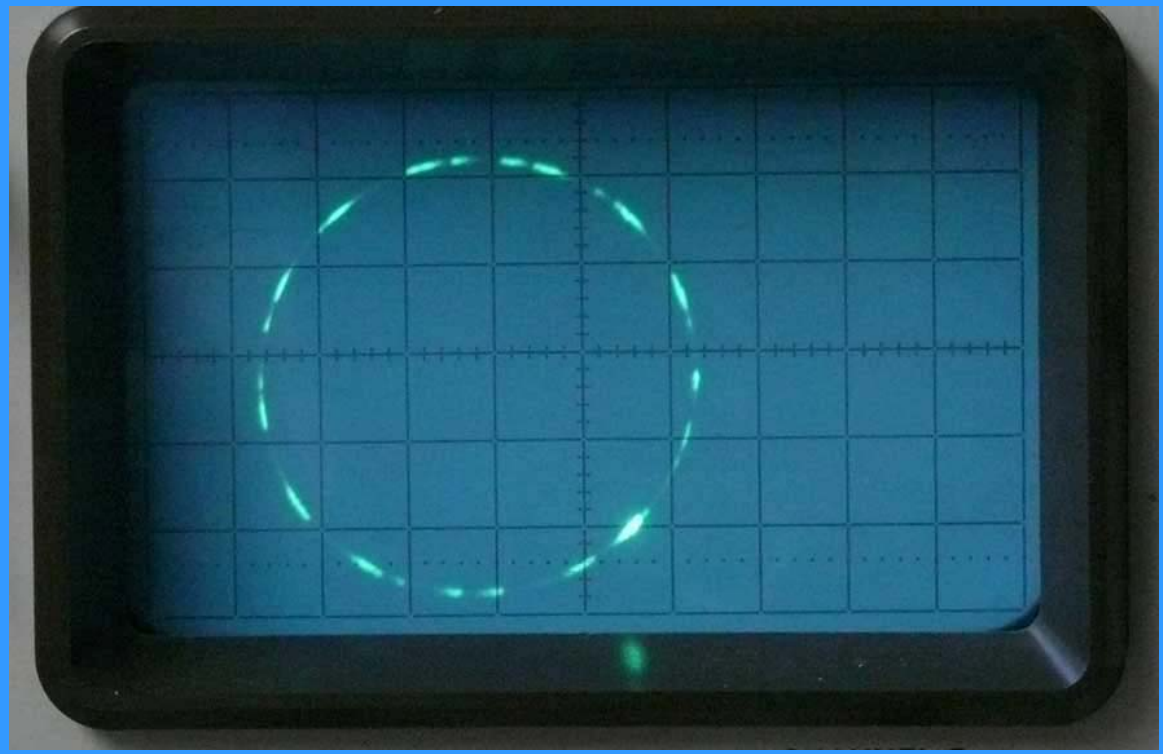
The blue line constitute the Nachtfee data the yellow ones the Nachtfee feedback signal (Neglecting the black EGON signals)

The dotted line constitute the added aircraft time-base reference TB



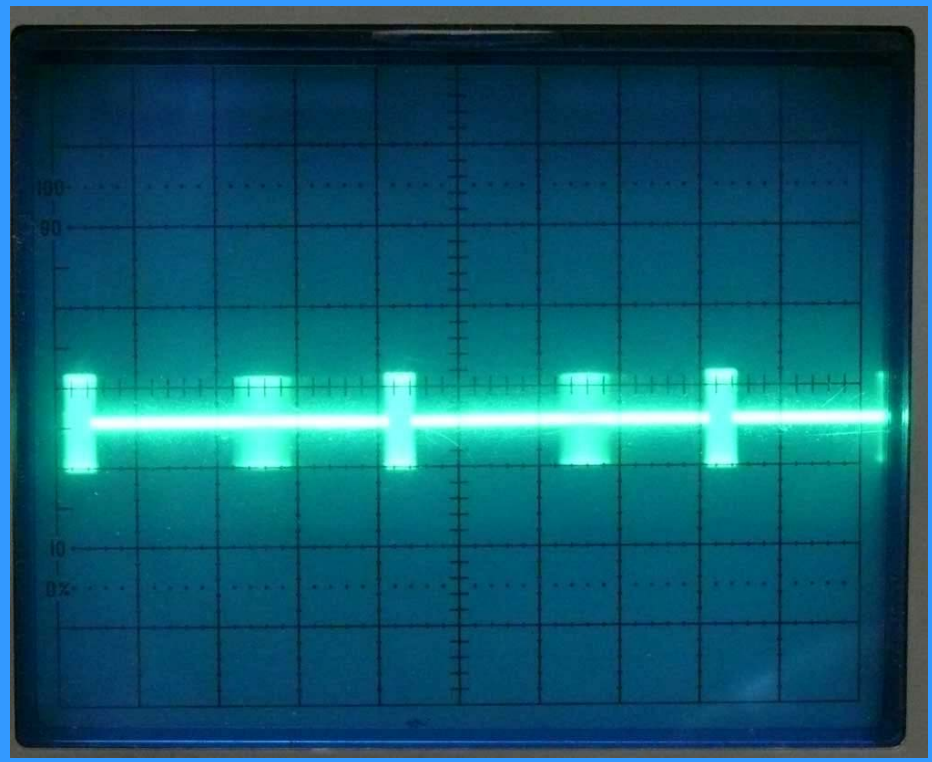


•For it we need a TB signal or phase reference, like the one at 45° (LB2)
We have seen that the correct domain of time setting is here at ≈ 45° (Control A)
•This guarantees that the Nachtfee due North pulse is manipulated such that it will arrive (pops-up) at the correct display vector in the aircraft
•Hence, the Nachtfee data signal is manipulated in a way, that constitute a feed-back (between A and B) as well; bringing both time-bases virtually in line
•The blue line-arcs constitute the variable phase correction (manually) of the Nachtfee 'order' upwards to the aircraft. Closing the loop into this direction



The a bit brighter spot is an example of an ‘order’ signal, painted at a simulated aircraft display; using a Lissajous. The dashes originate from the also available EGON pulses, though having a lower PRF (500 versus 506 Hz). These do not interfere with the actual Nachtfee data content. But is part of the combined EGON/Nachtfee signals

Very significant is the fact that the Lissajous due North is also the TB reference!



Viewing the combined HF signals send towards the simulated aircraft system

Nachtfee pulse being a bit smaller

The broader ones constitute the EGON pulses. Owing to its quick movements against the stationary Nachtfee pulse these appear broader than they actually are. Also the pulse durations are set longer than is necessary