Nachtfee
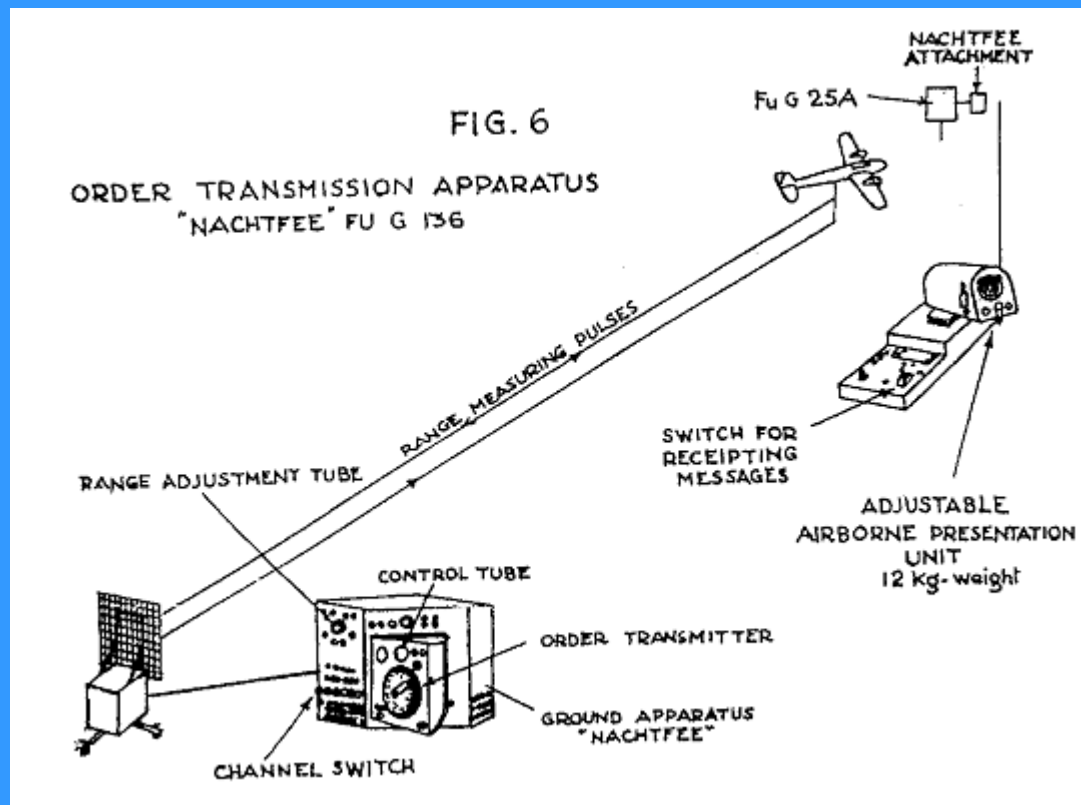# a once in a lifetime survey

By Arthur O. Bauer

**The picture I received early 2005.
Do you know this device?**

FIG. 6

ORDER TRANSMISSION APPARATUS
"NACHTFEE" FU G 136

NACHTFEE ATTACHMENT

Fu G 25A

RANGE MEASURING PULSES

RANGE ADJUSTMENT TUBE

SWITCH FOR RECEIPTING MESSAGES

ADJUSTABLE AIRBORNE PRESENTATION UNIT
12 kg-weight

CONTROL TUBE

ORDER TRANSMITTER

GROUND APPARATUS "NACHTFEE"

CHANNEL SWITCH

In September 2009, Phil brought along a copy of Radar News 19, German issue 25 February 1945

On 12 November 2011, we unpacked the crate of 95 kg
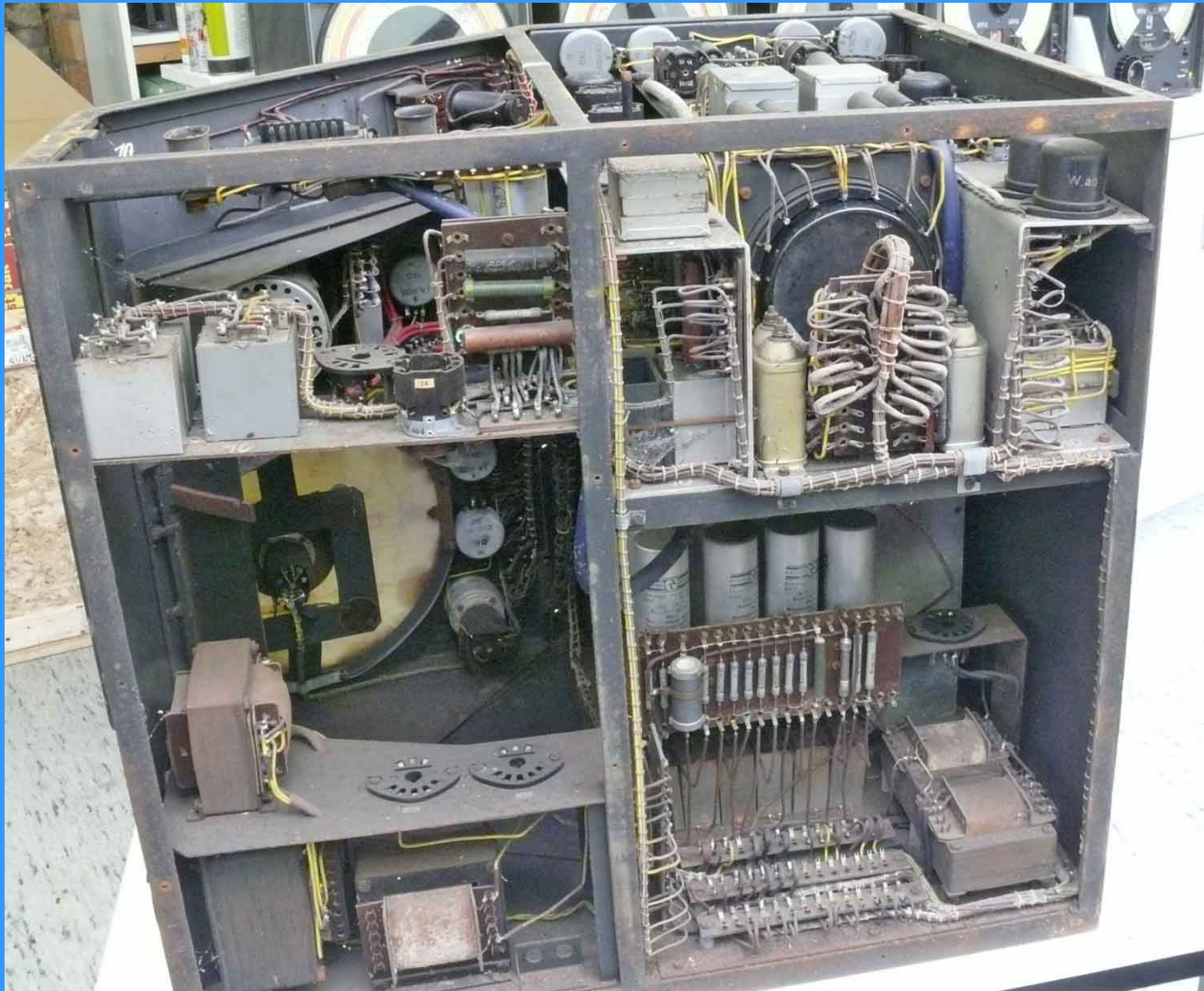
The rear and top cover plates being removed

What is the function of the 10 modules?

F. NORMAN
ROOM 11
HUT 3

MOST SECRET
No. 36

AIR SCIENTIFIC INTELLIGENCE

Report No. 101

GERMAN RADAR DEVELOPMENT

This Report must not be shown outside the following distribution without
reference to A.C.A.S.(I).

WAR CABINET   Copy No.
          Lord Cherwell   18
ADMIRALTY

**A.D.I. (S) Report 101 is R.V. Jones' first report on Nachtfee of March 1944.
Copy No 18 was addressed to Lord Cherwell,
Churchill's scientific advisor**

11. RECOGNITION.

11.1. Recognition is traditionally a difficult matter: the Germans have surpassed tradition.

11.2. Their analogue of I.F.F. was the FuGe 25, which was challenged on the Würzburg frequency (560 Mc/s), and replied on 150 Mc/s. Instead of displaying the returning pulses on the C.R. timebase with the echo, when the I.F.F. response could have been immediately associated with an echo at a particular range, the Germans put it on to a loud speaker or headphones. While this gave them the satisfaction of hearing the recognition signal in Morse (which was generated by a selectable cam arrangement in the aircraft), it lost them the valuable factor of range discrimination. It was therefore probably of little consequence that they had specially arranged for the challenging transmission to run at 5000 p.r.f., instead of the normal 3750; this meant that their timebase would then have been indicating incorrectly. They therefore had to cut out the C.R. presentation while challenging, and so lose sight of the target echo. Then, almost as though they were determined to make recognition as difficult as possible, they chose such a low response frequency (150 Mc/s) that the receiving array necessarily had a very wide angle of reception. Thus, having thrown away range discrimination, they followed this by abandoning angular discrimination, so that an aircraft with FuGe 25 anywhere near the target aircraft would emit the identifying signals. The only way in which the Germans could then achieve the necessary sharpness was to modify their receiving aerial to work on a minimum. Thus the final operation in this amazing chain was to press a switch, and then if the target was a friendly aircraft, the recognition signals disappeared; if they continued, it only indicated that there was a friendly aircraft in the neighbourhood; the Radar indication disappeared in either case. *

*In fairness, the FuGe 25 system had one virtue; it provided the Würzburg operator with a loudspeaker or headphones. The normal method of warning him to search was for an electric bell on the Würzburg to be rung by the control point. This bell had been placed in such a position on the Würzburg that it was almost inaudible to the operator. The designer therefore went to the length of putting a microphone by the bell and coupling it into the FuGe 25 circuit so that the operator could hear it on his headphones.

**11.1 Recognition is traditionally a difficult matter: the Germans have surpassed tradition**

The ten curious modules being removed. Leaving a magic box which function is unknown, only some few wires are linked with the main chassis
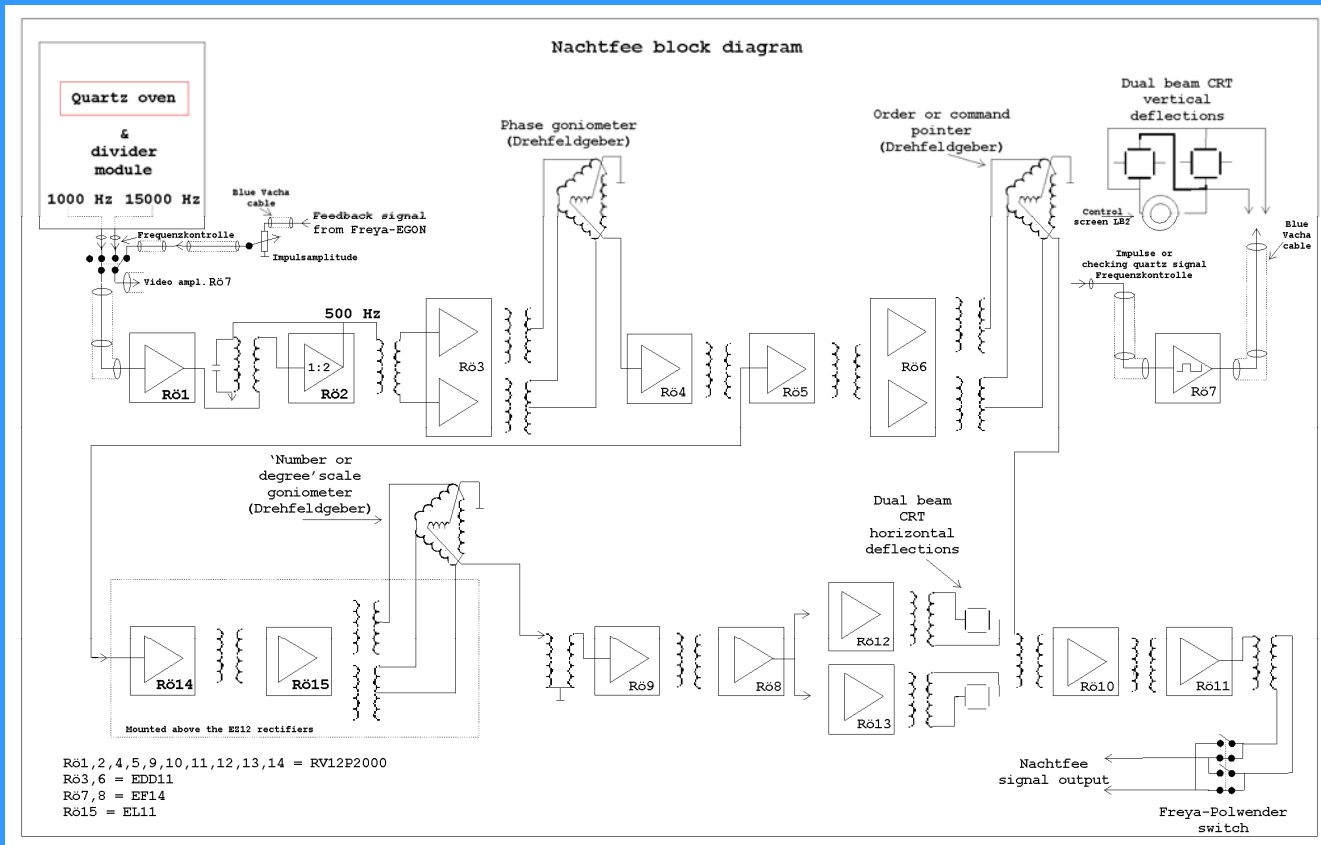
Cover plate being removed, viewing a white insulation plate, apparently consisting of brittle glass-fibres
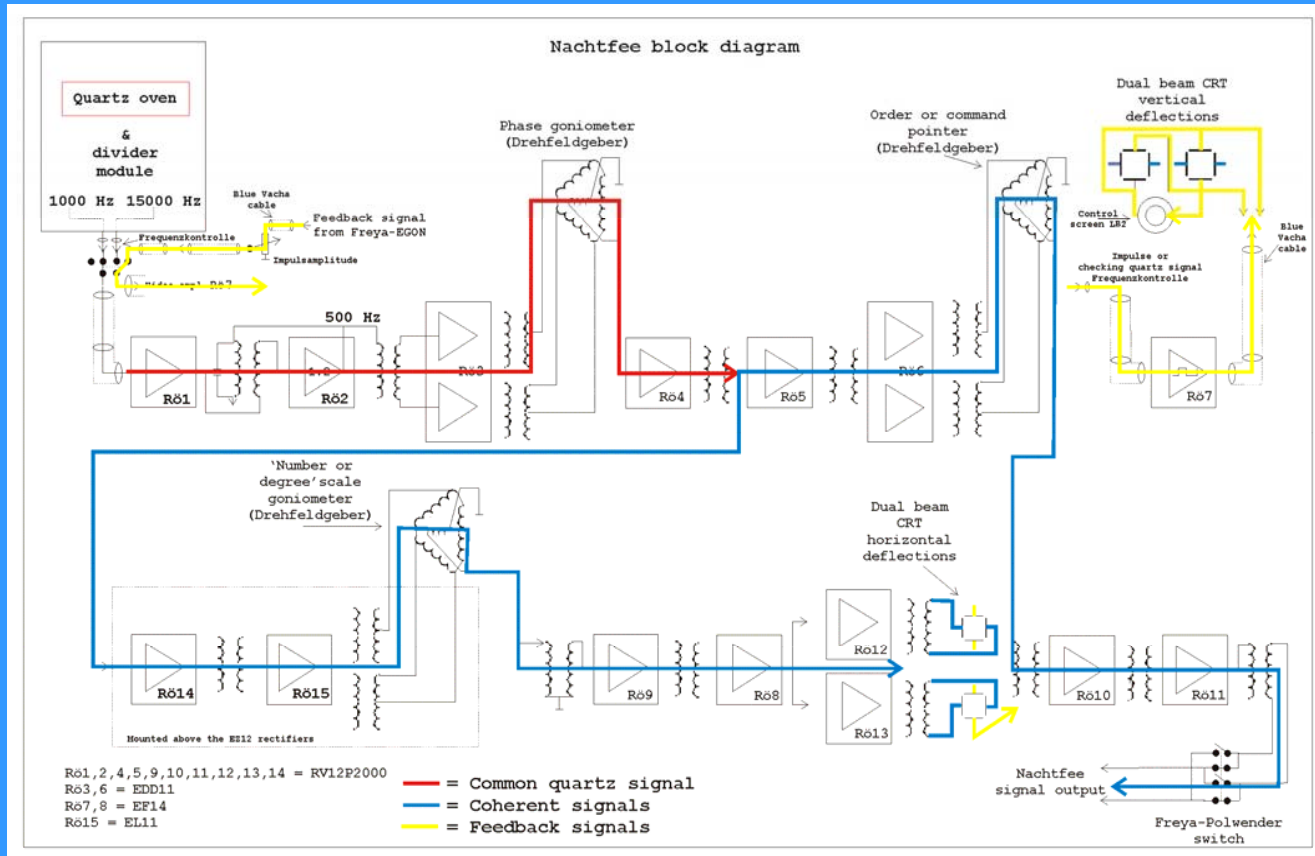
A complete surprise discovering ten quartz crystals + and - 15,000 Hz each separated by 60 Hz steps
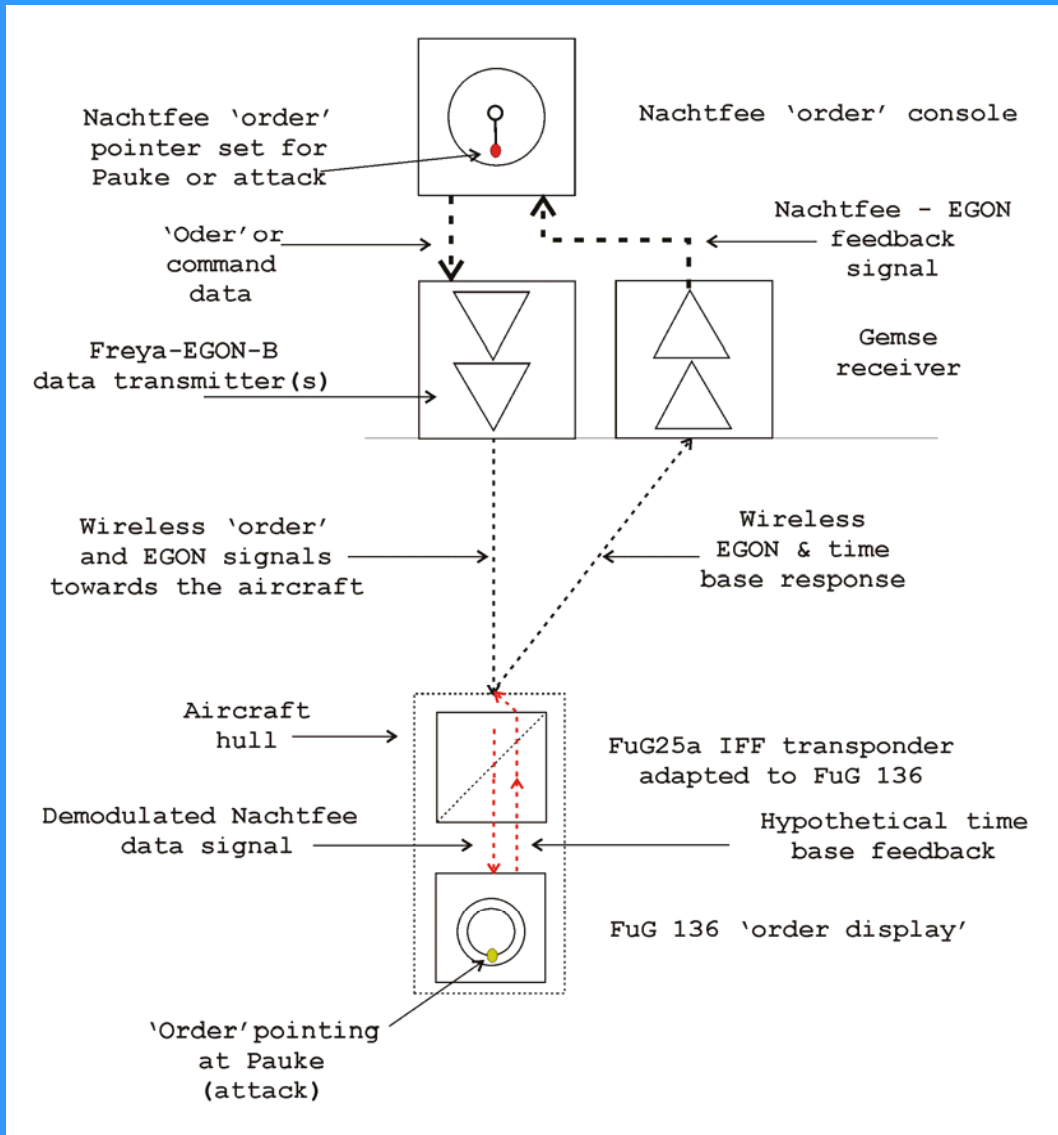
My first system concept, which proved being correct

The Nachtfee block diagram
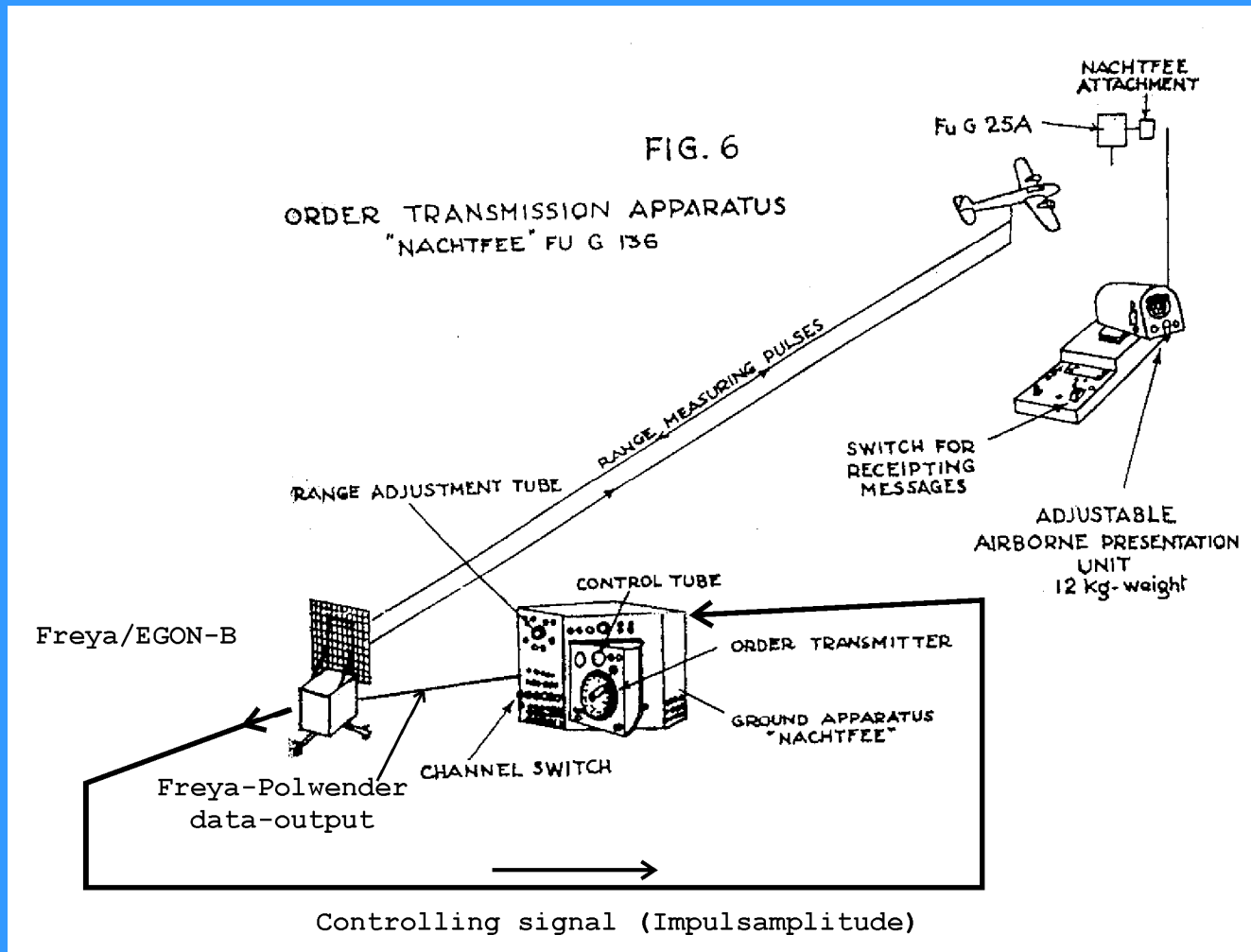
Nachtfee block diagram

The blue signals are coherent, the red line is the central signal source (Phase), the yellow lines having control functions

What is the purpose of this scale?

**One deflection system writes from right to the left
the other system from left to the right
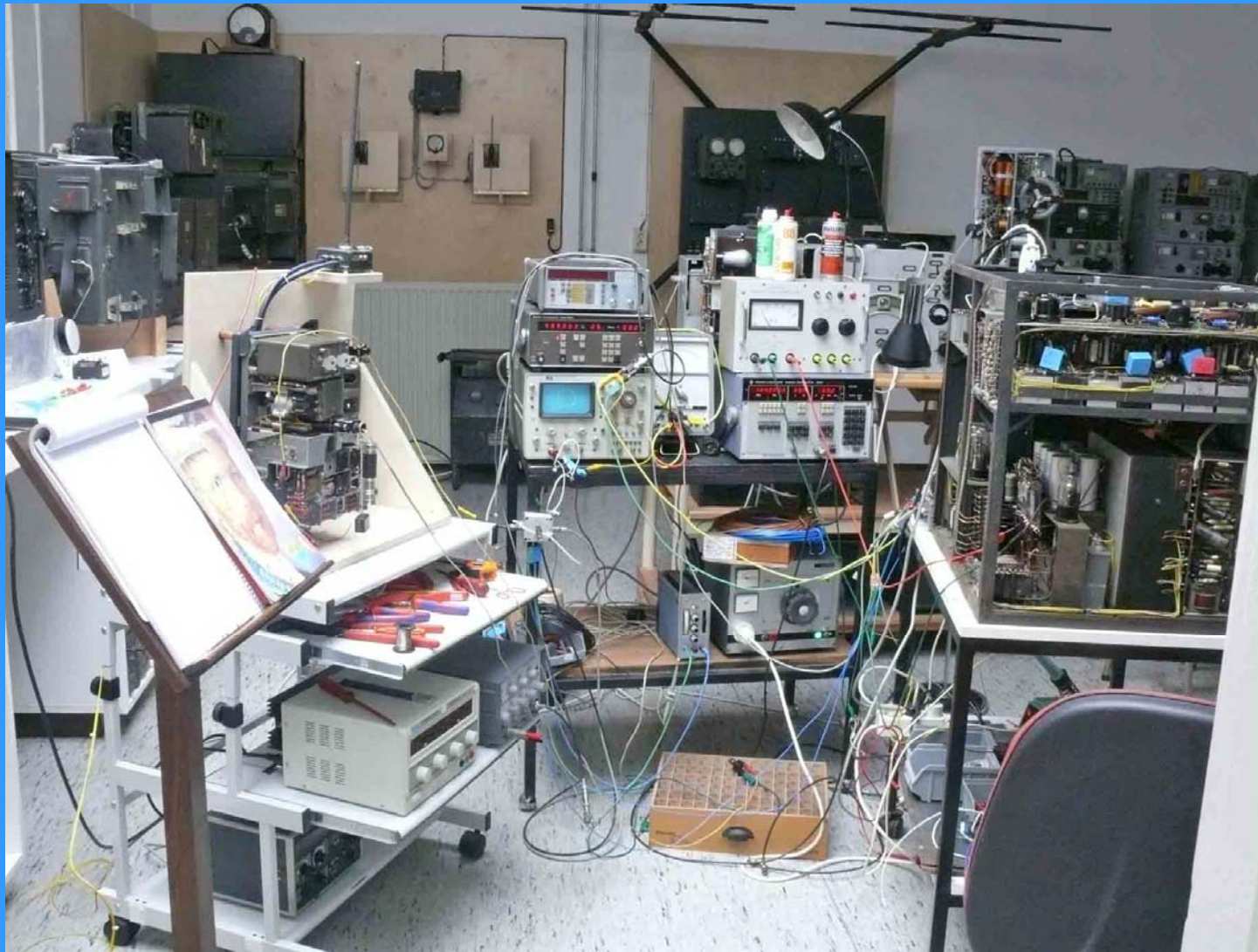the vertical system being connected back-to-back**

FIG. 6

ORDER TRANSMISSION APPARATUS
"NACHTFEE" FU G 136

NACHTFEE ATTACHMENT

Fu G 25A

RANGE MEASURING PULSES

RANGE ADJUSTMENT TUBE

SWITCH FOR RECEIPTING MESSAGES

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CONTROL TUBE

Freya/EGON-B

ORDER TRANSMITTER

GROUND APPARATUS "NACHTFEE"

CHANNEL SWITCH

Freya-Polwender data-output

Controlling signal (Impulsamplitude)

A crucial brain wave: the Nachtfee data-output should be feed back onto the controlling channel inside the Nachtfee console

Wow, the first signs of life
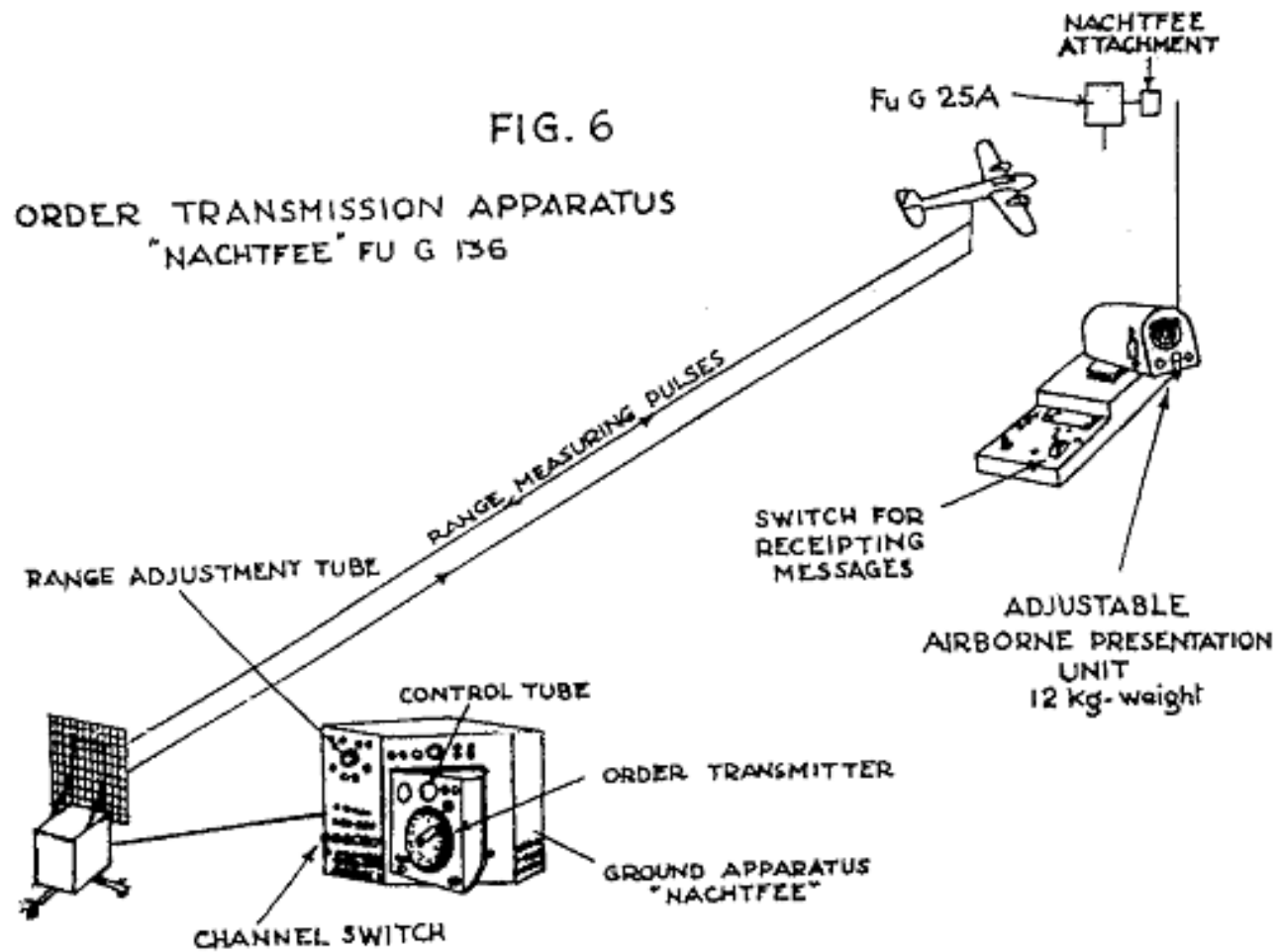
The FuG 25a IFF setup

How Nachtfee works

explaining its fundamentals

a bit

differently

FIG. 6

ORDER TRANSMISSION APPARATUS "NACHTFEE" FU G 136

NACHTFEE ATTACHMENT

Fu G 25A

RANGE MEASURING PULSES

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GROUND APPARATUS "NACHTFEE"

CHANNEL SWITCH

Finding this drawing forms the nucleus of our Nachtfee survey

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.

Nachtfee
A navigational aid

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

• 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

What is the fundamental control problem?

Let us imagine that an aircraft stood next to a Freya-Nachtfee station. Both systems watching the same 'order' or command signal, say, pointing due North. Considering both time-base references having exactly the same signal phase

What will happen when the aircraft takes off and is flying in a straight line towards a target?

The signal pulse (blip) painted on the aircraft display will start moving anti-clockwise. The changing 'order' vector being a function of the aircraft speed and distance

Therefore, distance (Range off-set) and the actual aircraft time-base reference (Phase) should be both controlled by the Nachtfee ground console crew. Thus, manually!
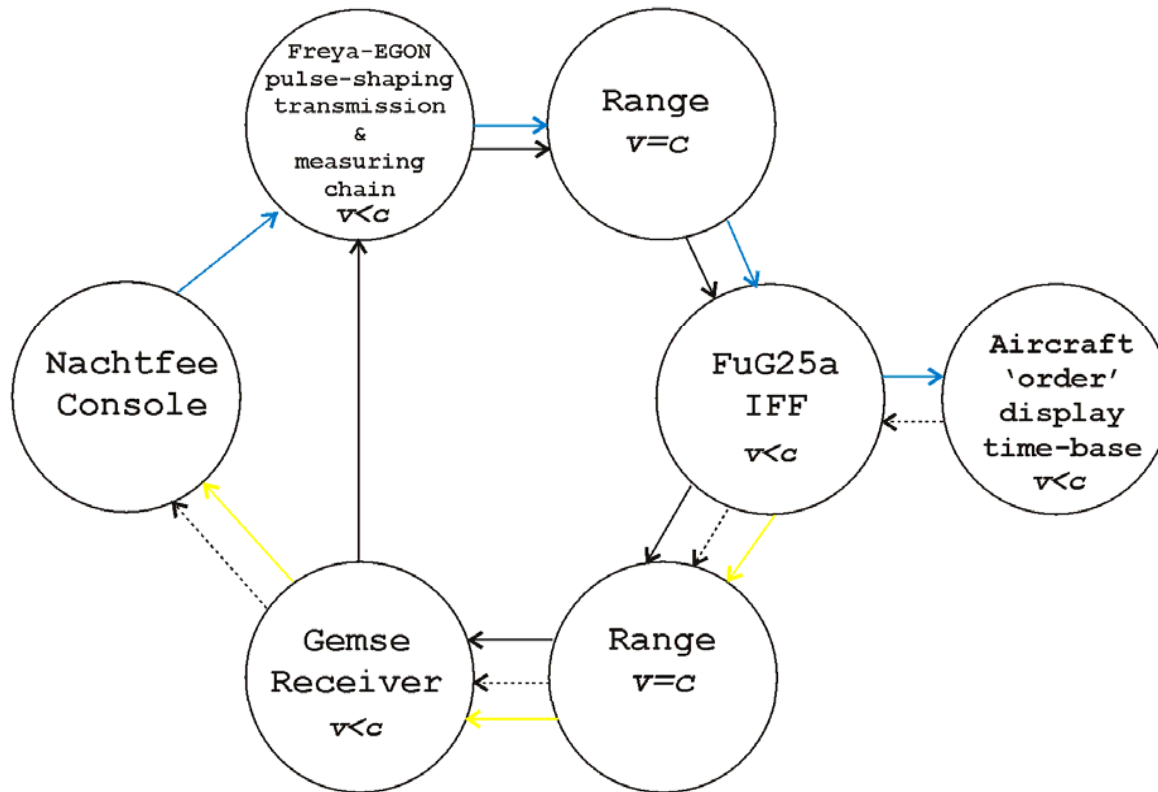
As to get an idea on which principle Nachtfee is relying I would like to use an analogy

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 relied on closed loops

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 the 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 4th 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!
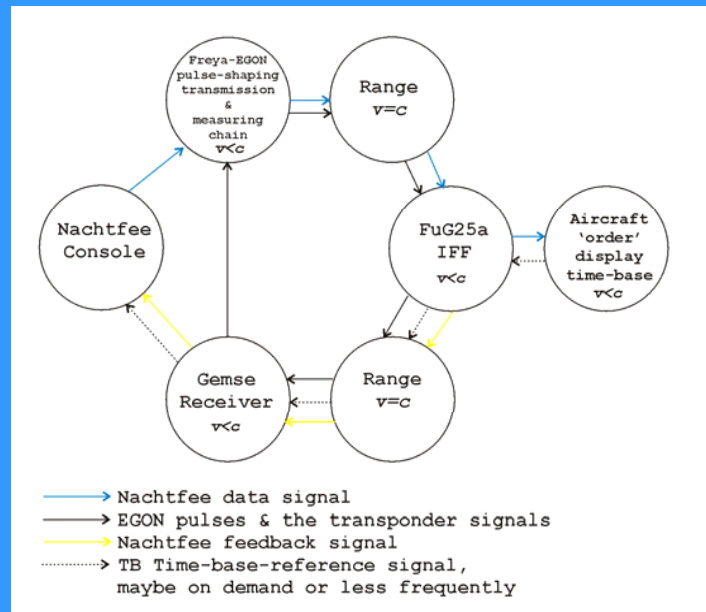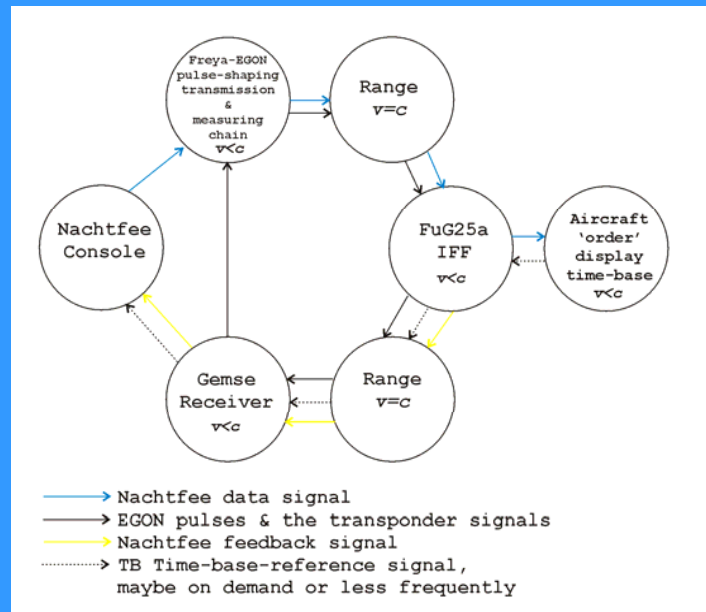
The Nachtfee system consists of two feedback loops

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
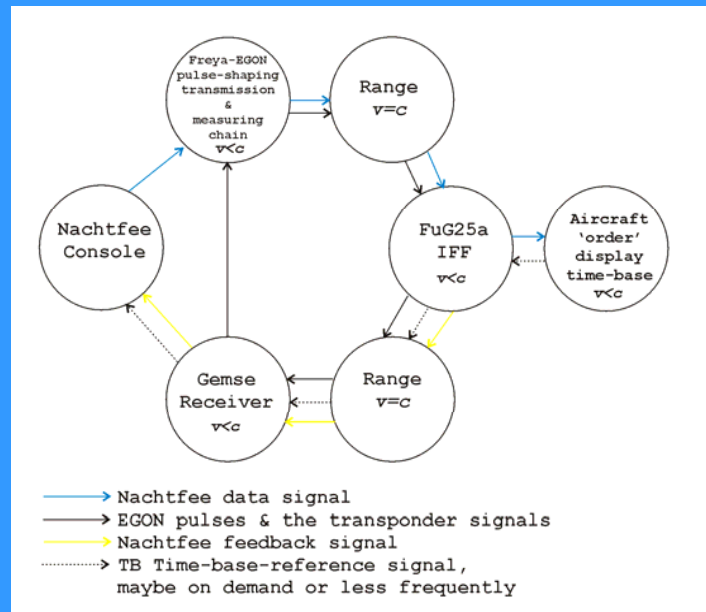
The diagram shows a loop of circles:
- Freya-EGON pulse-shaping transmission & measuring chain v≪c
- Range v=c
- FuG25a IFF v≪c
- Aircraft 'order' display time-base v≪c
- Range v=c
- Gemse Receiver v≪c
- Nachtfee Console

Legend:
→ Nachtfee data signal
→ EGON pulses & the transponder signals
→ Nachtfee feedback signal
⤍ TB Time-base-reference signal, maybe on demand or less frequently

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*!

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

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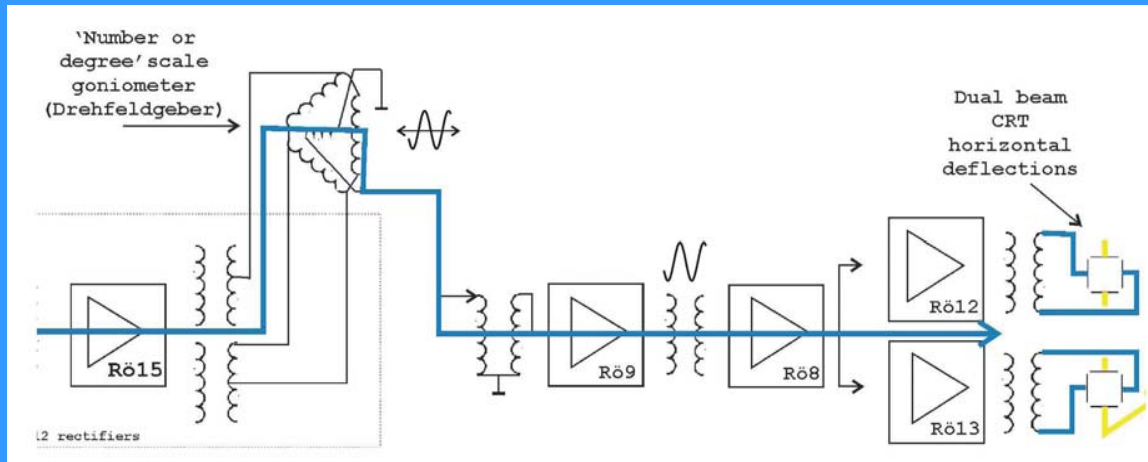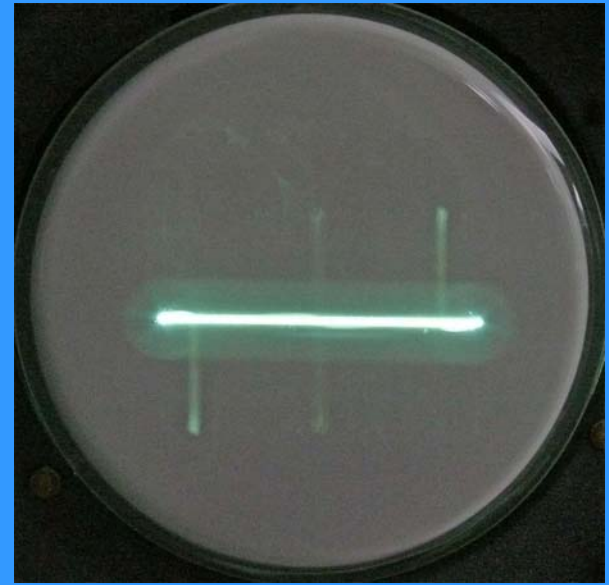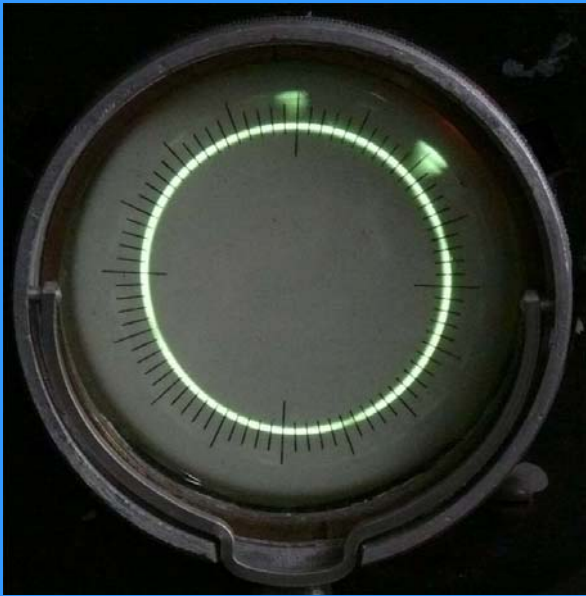
Due north on the left is the Nachtfee feedback pulse adjusted back-to-back in the centre of the dual trace CRT correctly; by means of the number or 'Range off-set' control. Using the goniometer on the left-hand side

A = without scale
B = 'order' compass
C = Range off-set in km
A = B = C phase goniometers
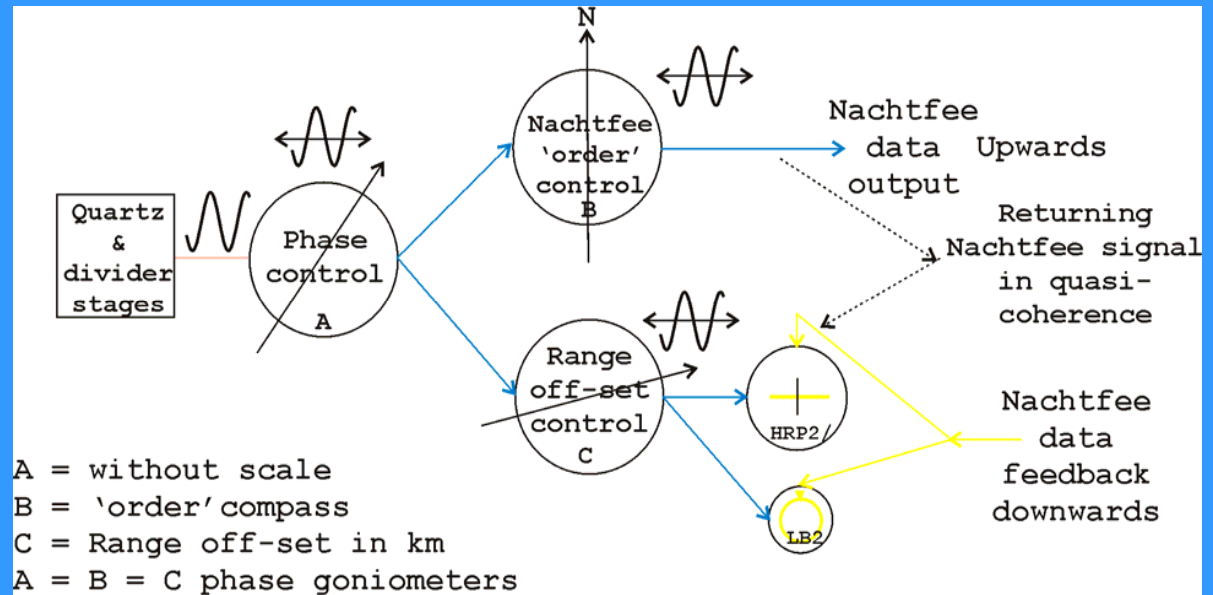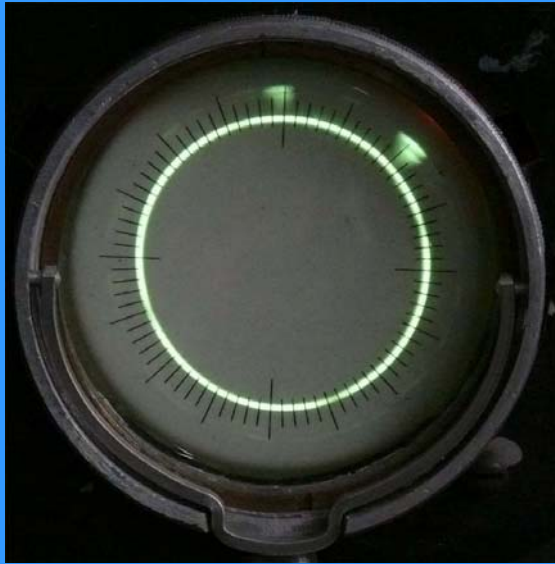
Firstly, the pulse due North is correctly adjusted by means of goniometer C

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)

A = without scale
B = 'order' compass
C = Range off-set in km
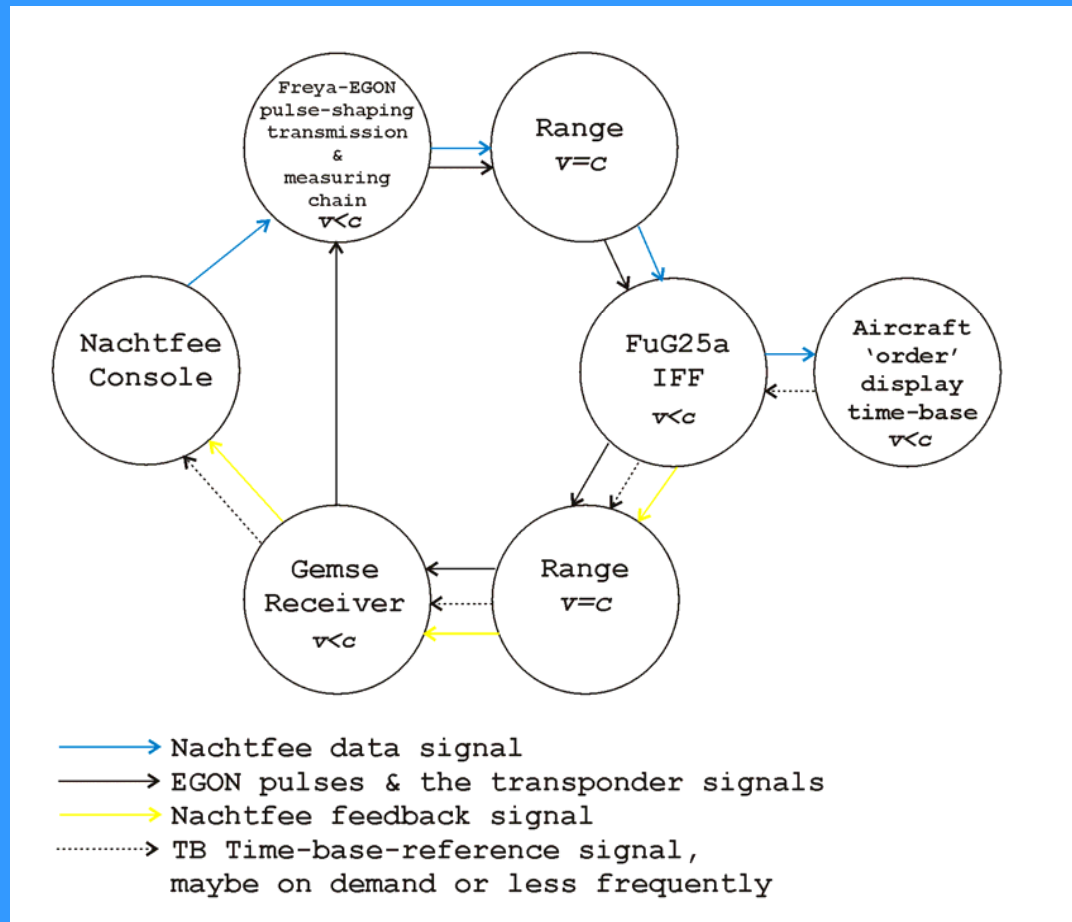A = B = C phase goniometers
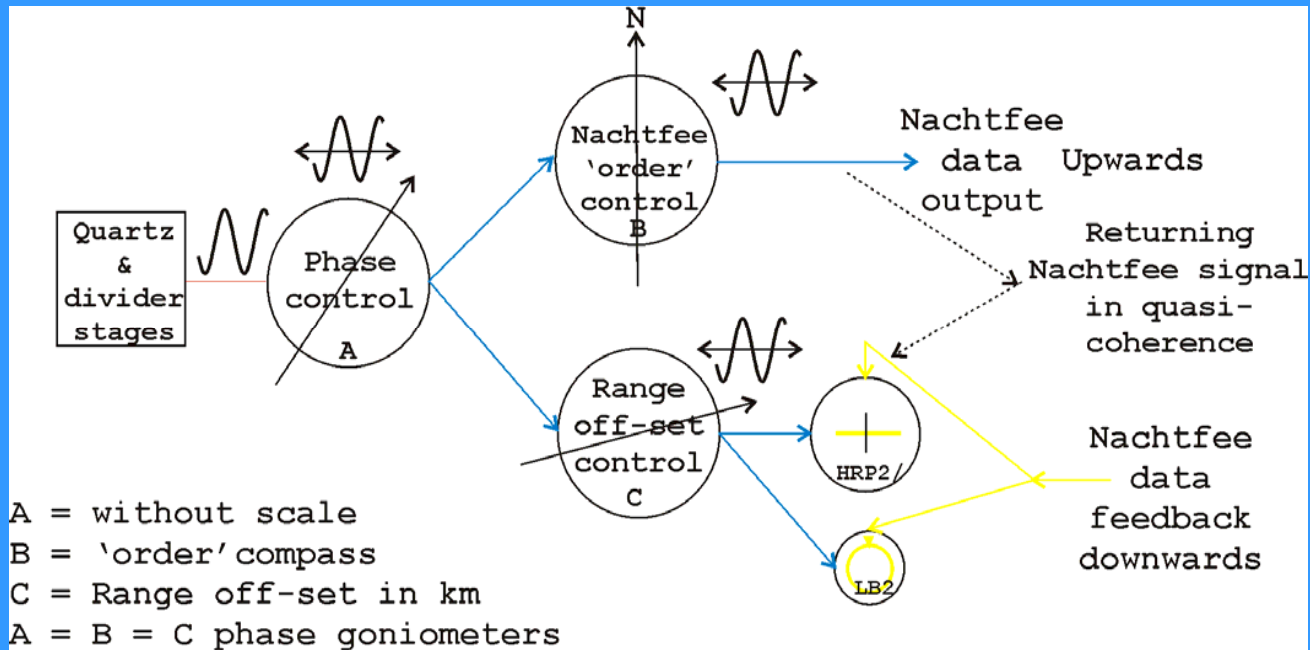
Goniometer control B is the actual 'order' or command compass

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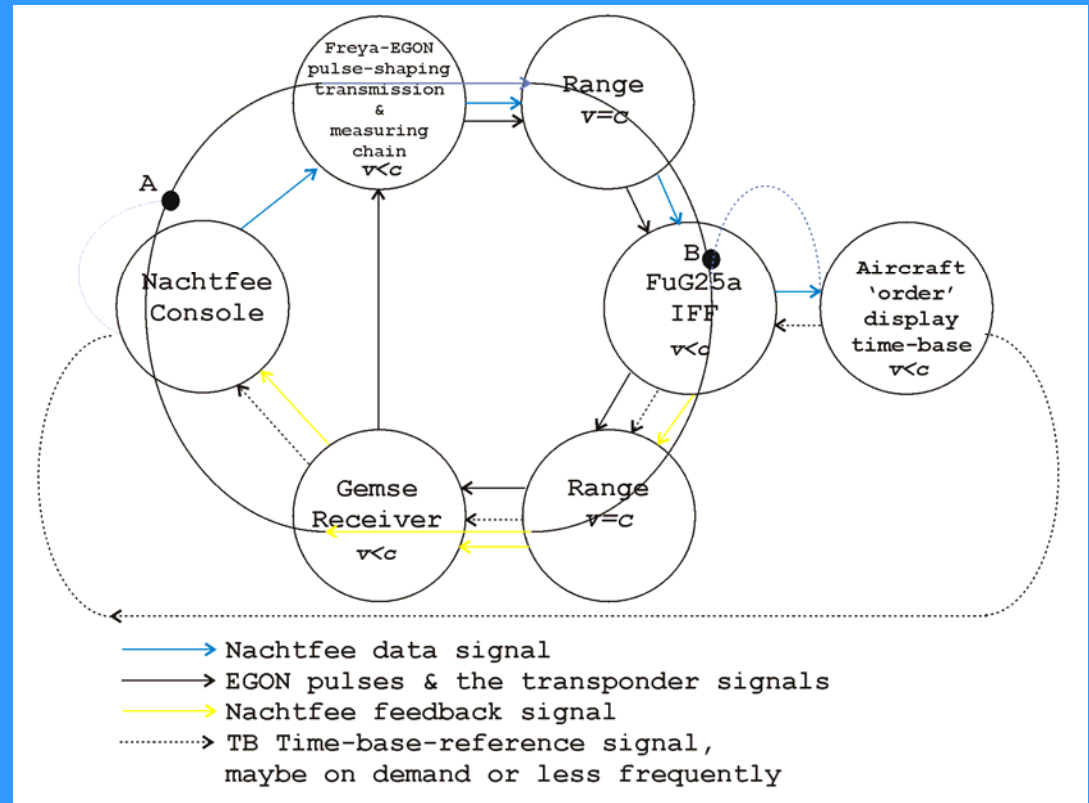
Though, how is ascertained that the 'order' blip appears correctly?

Freya-EGON
pulse-shaping
transmission
&
measuring
chain
$v<c$

Range
$v=c$

Nachtfee
Console

FuG25a
IFF
$v<c$

Aircraft
'order'
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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

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

	Nachtfee data signal
	EGON pulses & the transponder signals
	Nachtfee feedback signal
	TB Time-base-reference signal, maybe on demand or less frequently

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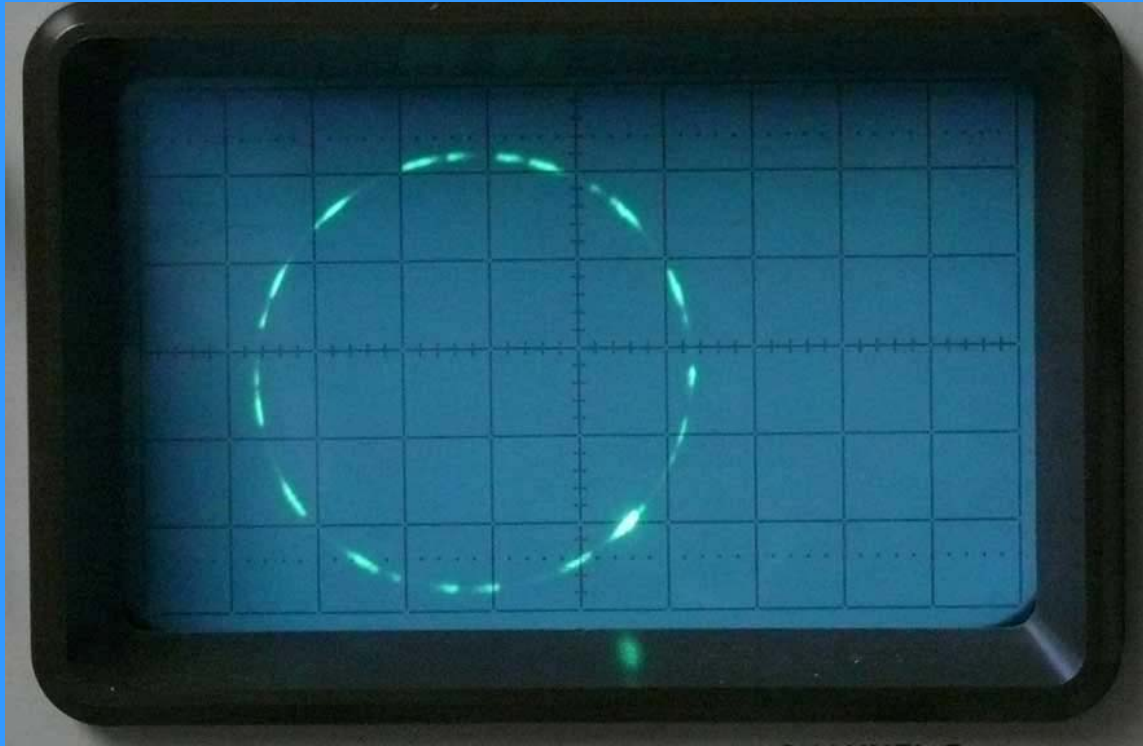
The a bit brighter spot is an example of an 'order' signal, painted at a simulated aircraft display; using a Lissajous. The dashes originate from the also available EGON pulses, though having a lower PRF (500 versus 506 Hz). These do not interfere with the actual Nachtfee data content. But is part of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

Very significant is the fact that the Lissajous due North is also the TB reference!
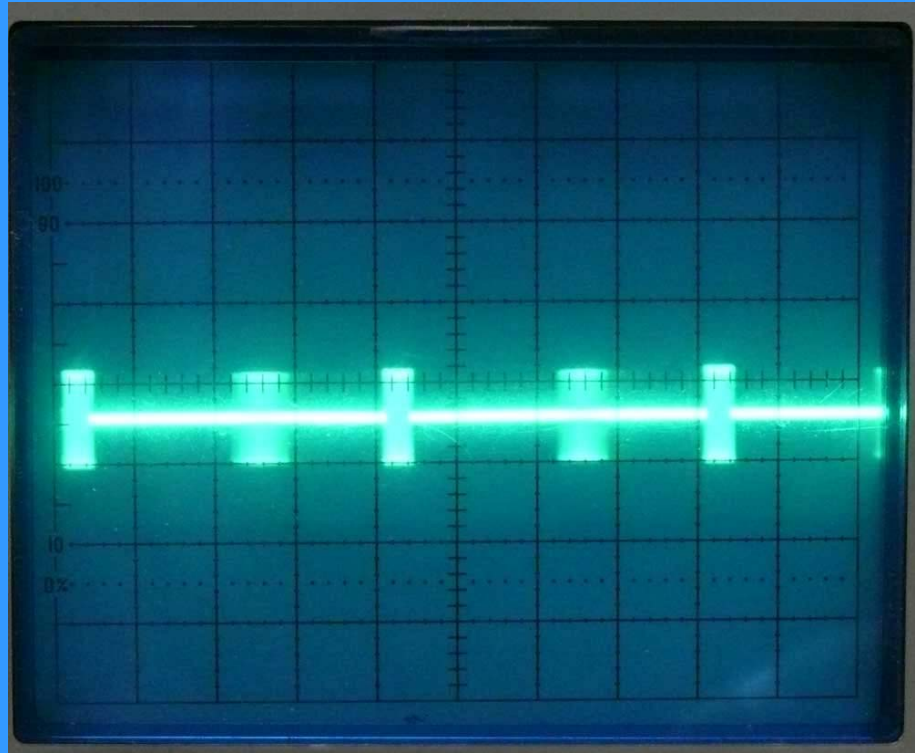
Viewing the combined HF signals send towards the simulated aircraft system

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

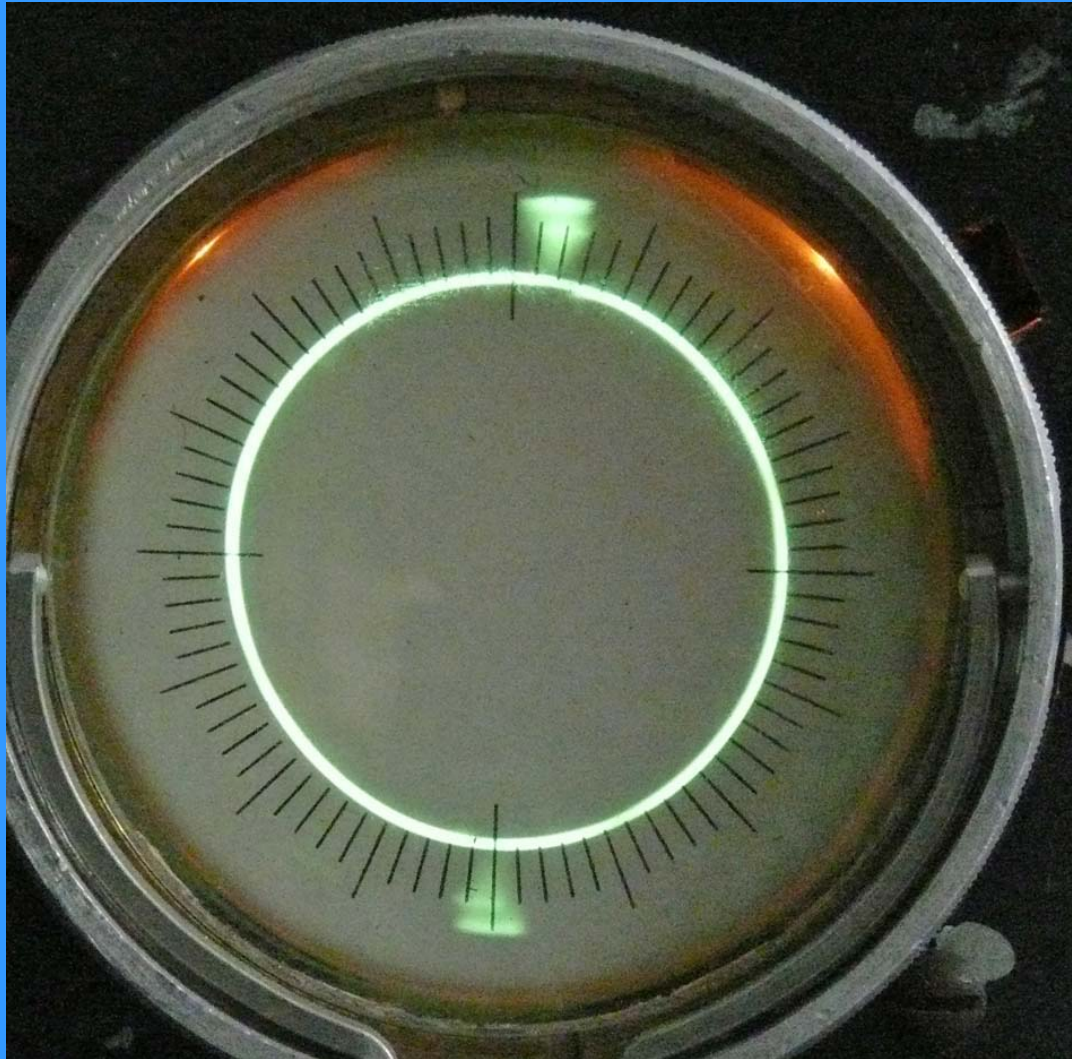**After the experimental stage was concluded a final place had to be created**

Viewing the simulated transmission section.
The upper generator constituting the 500 Hz EGON-PRF

The preliminary simulated aircraft display set up
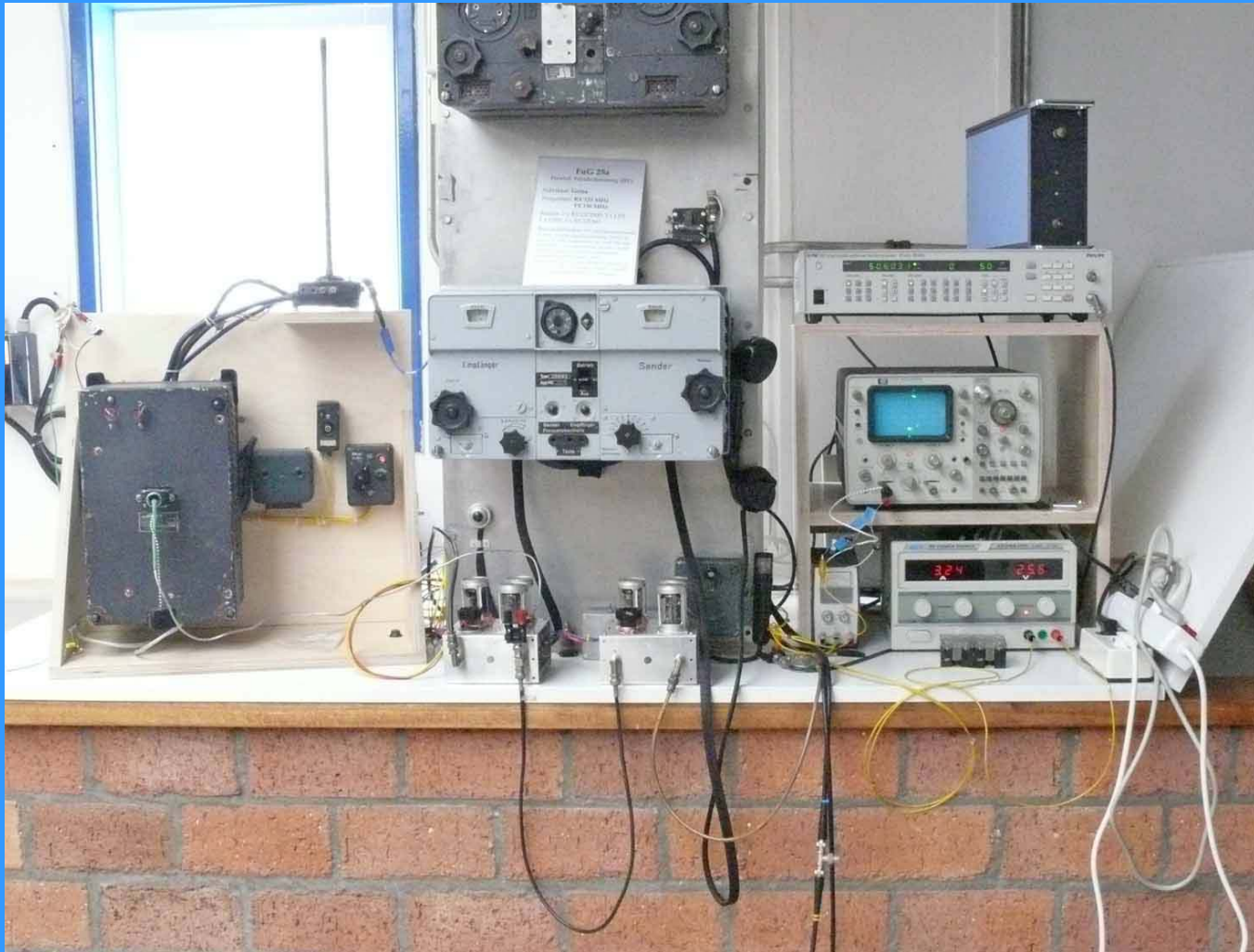**September 2012**

**Watching the FuG 25a signal output at pin 9 of the test connector**
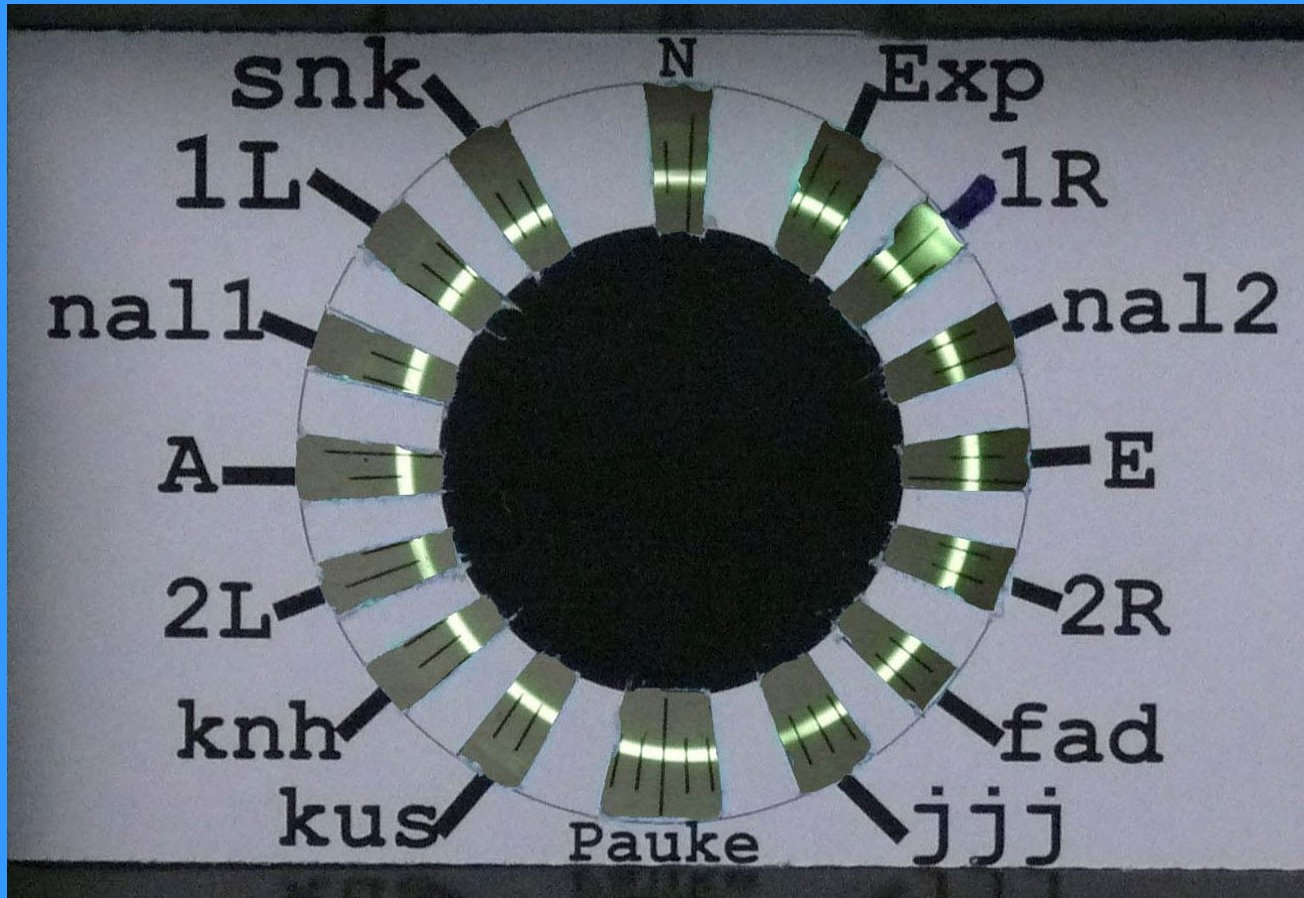
The blip due South represents the Nachtfee waiting signal, operating 'Freya-Polwender' mode. The upper signal being the to be 'Phase' regulated aircraft TB ref. signal

The current, likely final set up
On the left the FuG 25a IFF transponder, in the centre two interfaces, on the right the time-base-reference on top of the simulated aircraft display
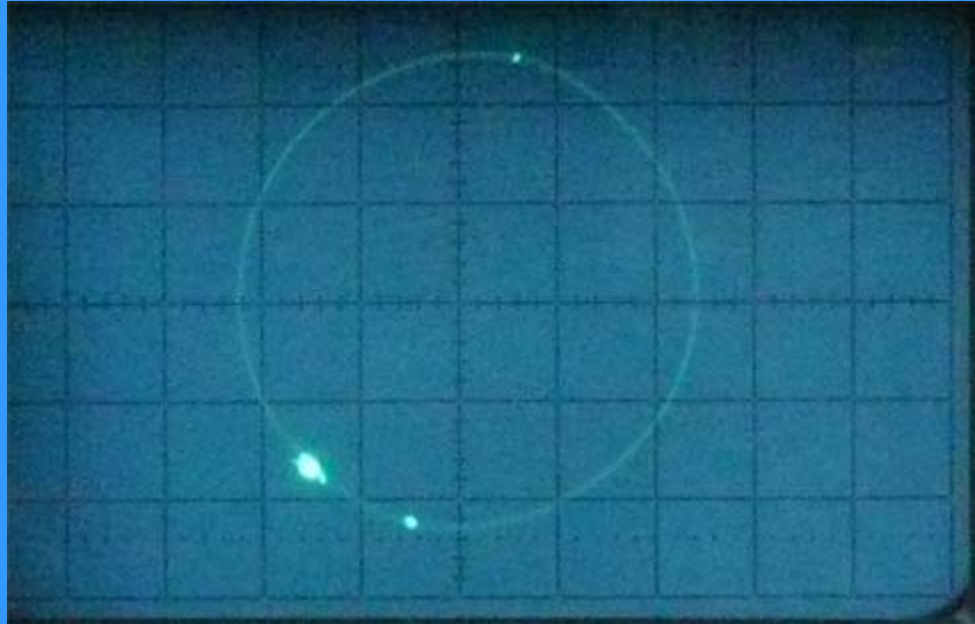
Viewing the simulated aircraft 'order' or command display

www.cdvandt.org