"....the Battle of France is over,

…the Battle of Britain is about to begin."

WINSTON CHURCHILL June 18, 1940

A Race on the Edge of Time

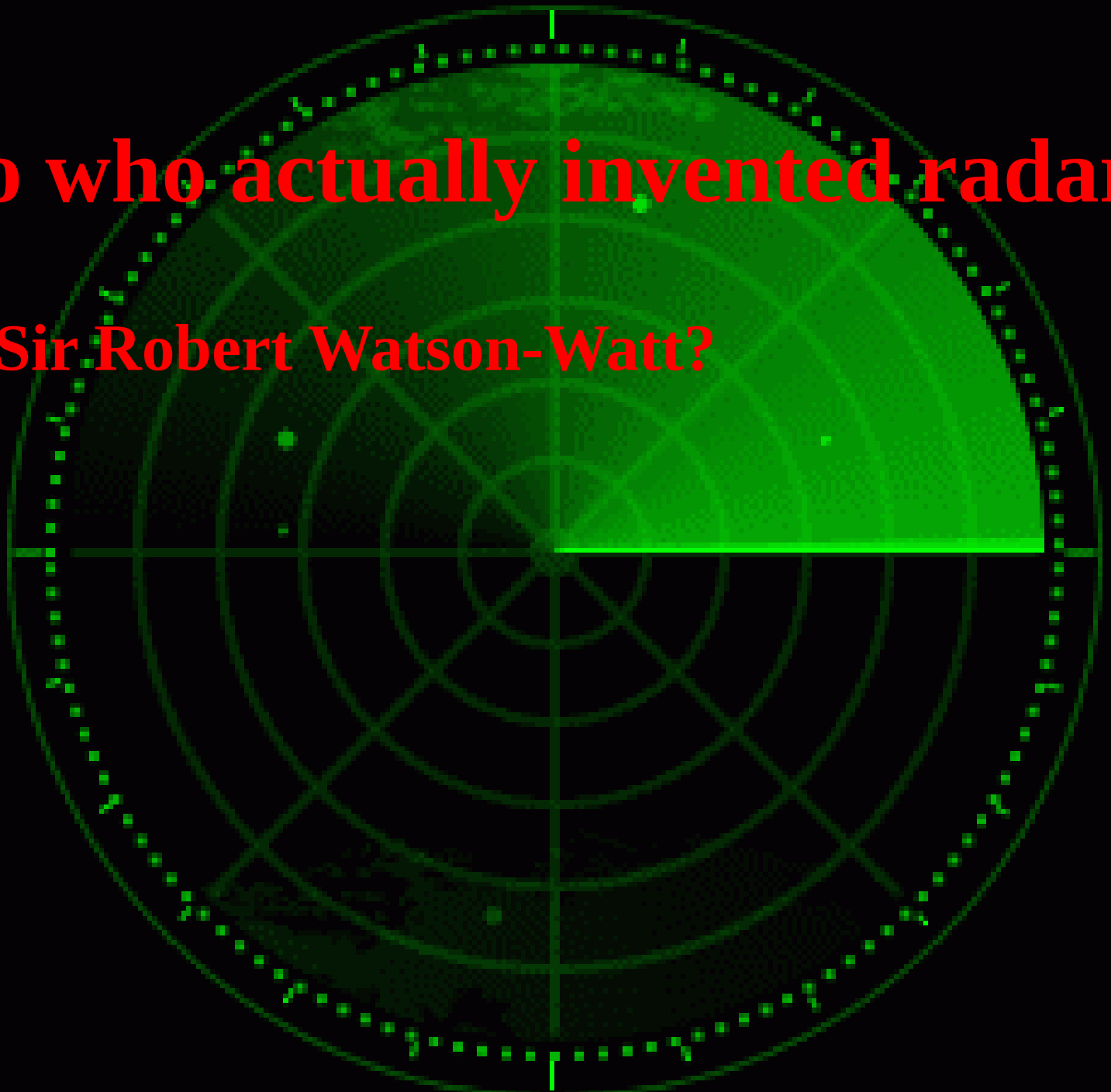
Development of the British Air Defence System and the Battle of Britain

Alphonse Penney
VO1NO

So who actually invented radar?

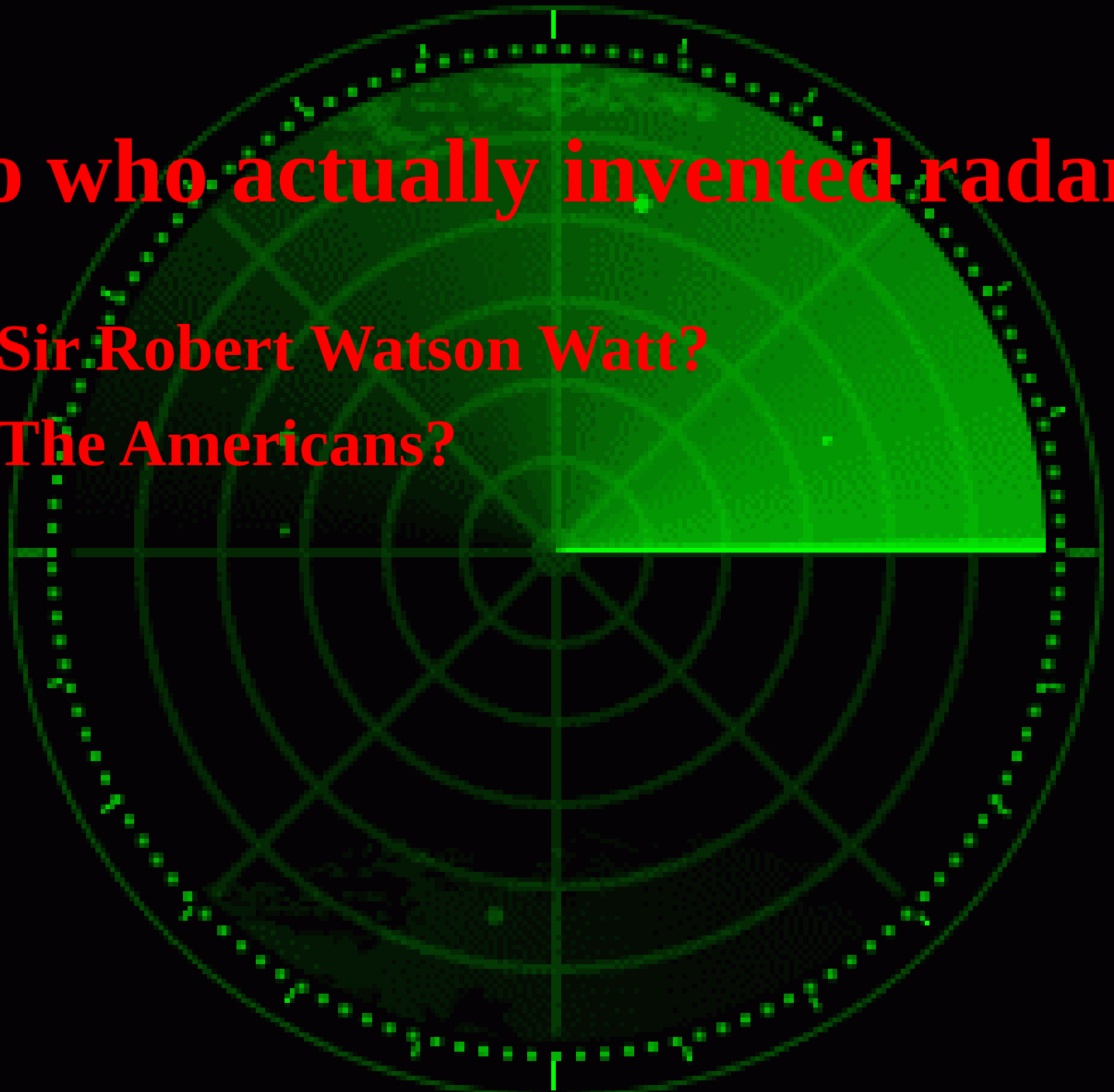
So who actually invented radar?

- Sir Robert Watson-Watt?



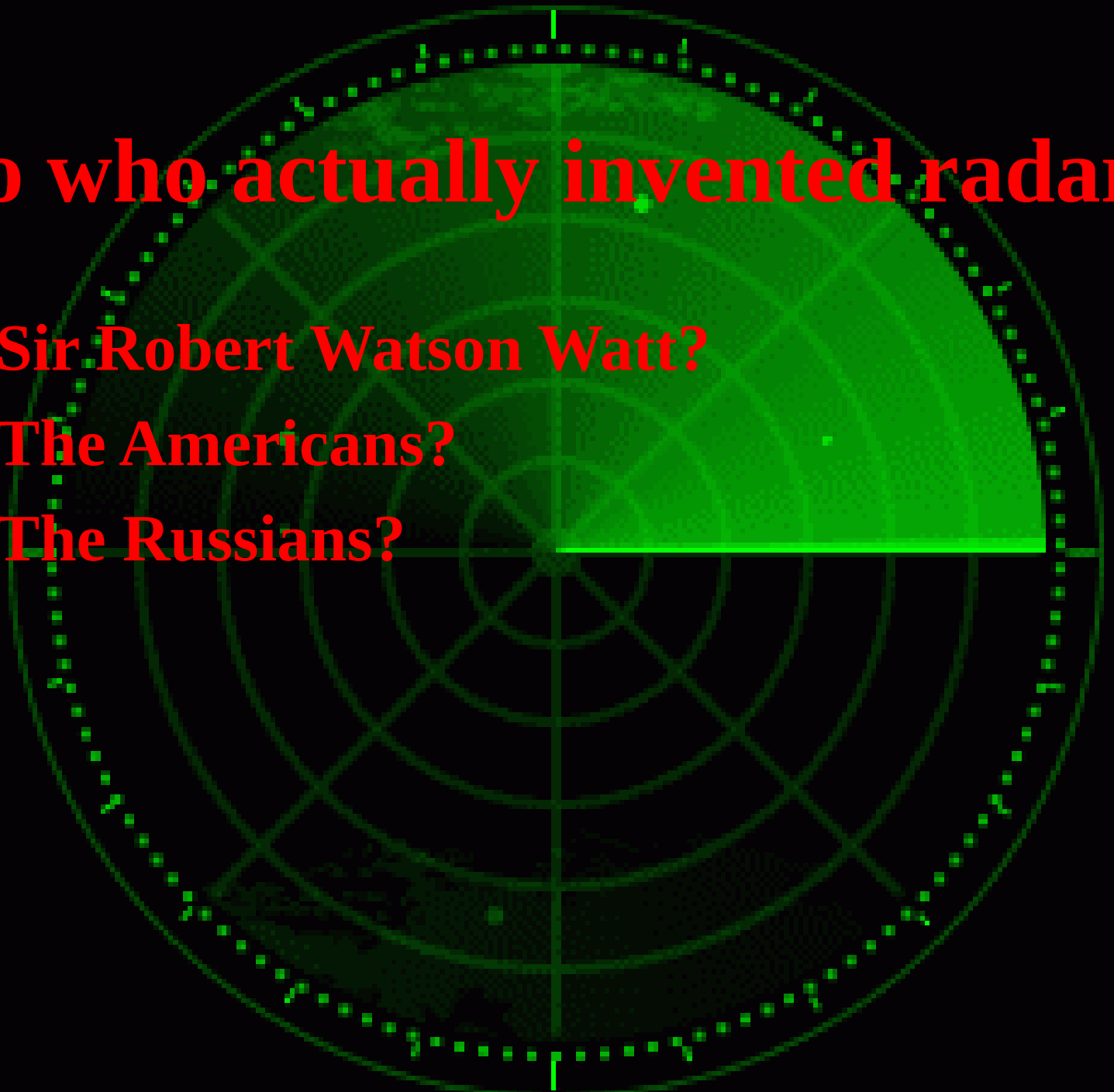
So who actually invented radar?

- Sir Robert Watson Watt?
- The Americans?



So who actually invented radar?

- Sir Robert Watson Watt?
- The Americans?
- The Russians?



So who actually invented radar?

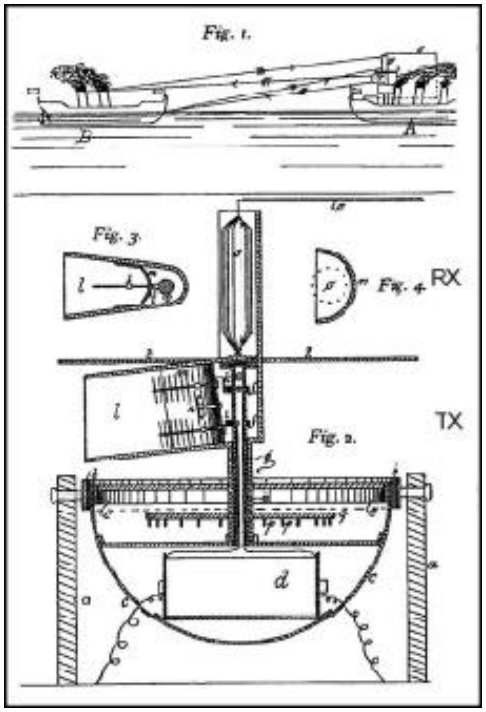
- Sir Robert Watson Watt?
- The Americans?
- The Russians?
- The Japanese?

So who actually invented radar?

- Sir Robert Watson Watt?
- The Americans?
- The Russians?
- The Japanese?
- Actually, it was invented by a number of people over long period of time.

- In 1895 Alexander Popov noted interference caused by the passage of a ship.
- In 1904 Christian Hülsmeyer patented his Telemobiloscope for detecting the presence of a ship in fog.

Hülsmeyer's Telemobiloscope



- In the 1920s and 30s, many scientists and engineers developed systems that eventually evolved into what we now call radar.
- In the UK, Sir Robert Watson-Watt and “Skip” Wilkins were the brainchildren behind British Radar.

“The Bomber will always get through.”

Stanley Baldwin
Lord President of Great Britain
1932

- In the 1930s, most people believed that it was not possible to stop a determined bombing offensive.
- Early warning used acoustic detectors – not very effective as the speed of airplanes increased in the 1920s and 1930s.

The first (British) steps…

- Having witnessed the disruption caused by the milkman in 1934, A. P. Rowe sent his boss, H. E. Wimperis, a memo warning that unless a solution was found, England faced destruction from enemy bombers.
- That memo initiated a chain of events that ultimately saved Great Britain, and probably most of the world, from Nazi domination!

- Wimperis wrote to the Secretary of State for Air, and the head of RAF's Research and Development department, Air Marshall Sir Hugh Dowding, recommending the formation of a committee to

  "consider how far recent advances in scientific and technical knowledge can be used to strengthen the present methods of defence against hostile aircraft."

Air Chief Marshal Sir Hugh Dowding

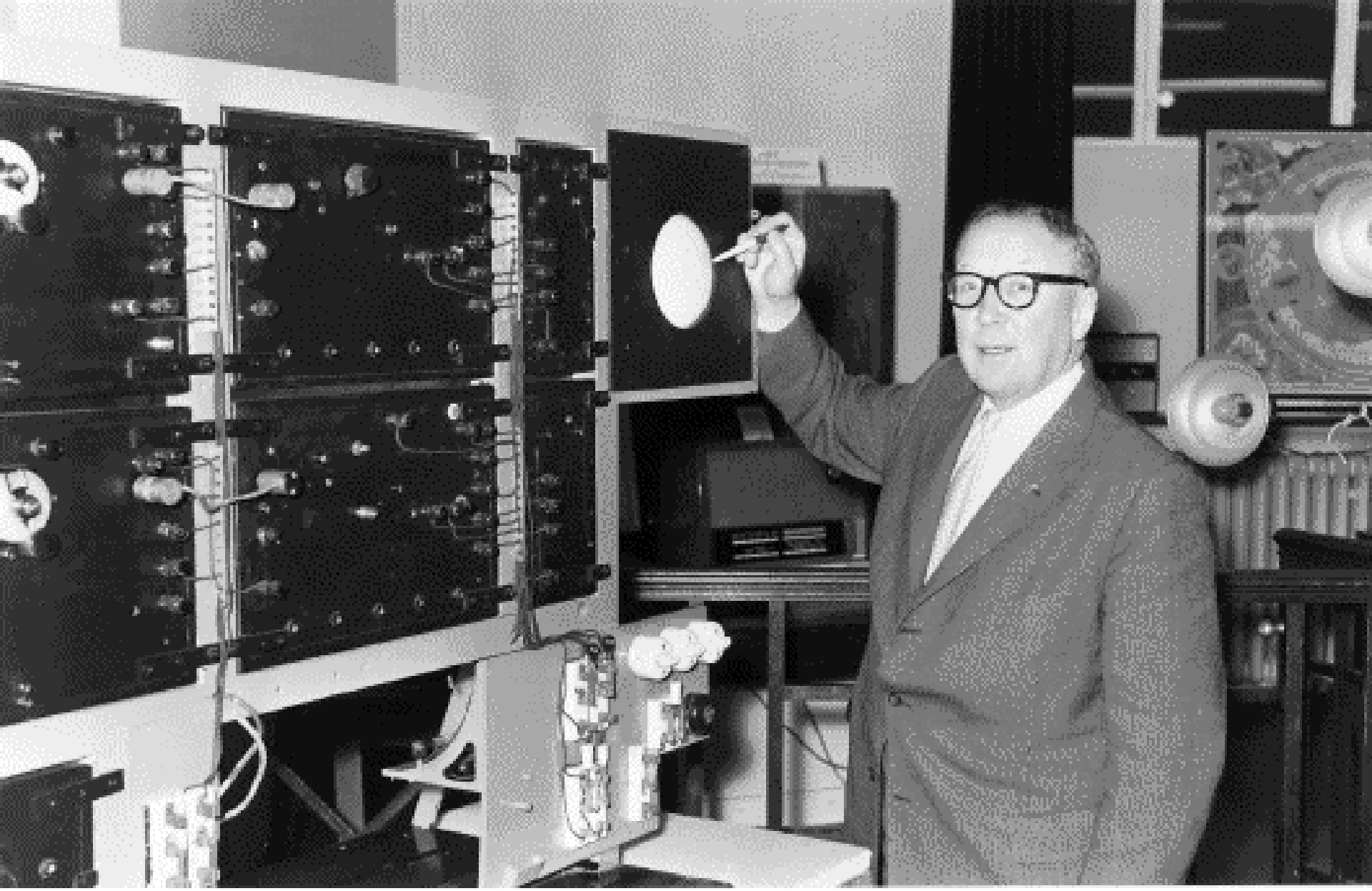
The Committee for the Scientific Survey of Air Defence

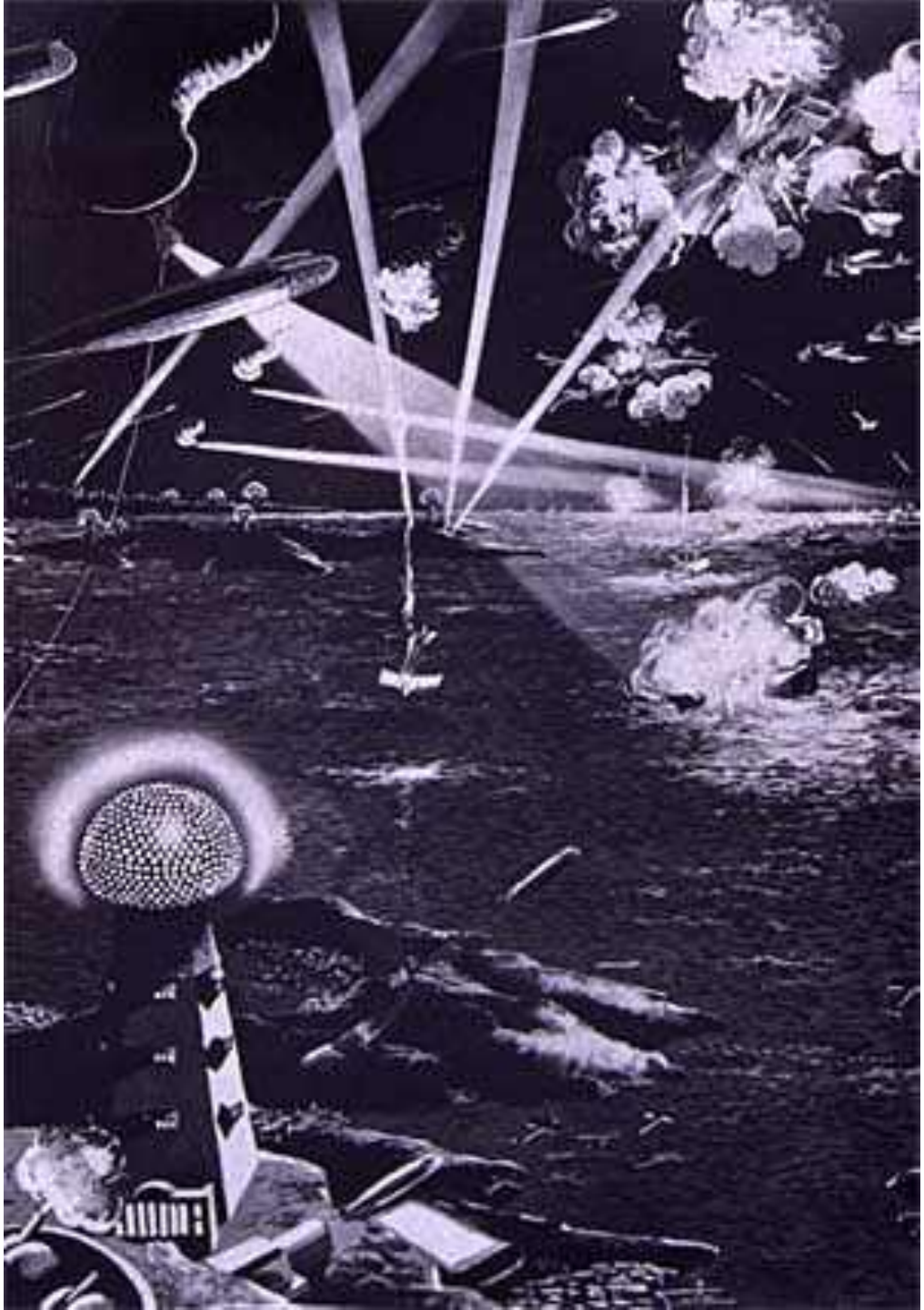
- Dr. H. T. Tizard (Chairman)
- Professor A. V. Hill
- Professor P. M. S. Blackett
- Dr. H. E. Wimperis
- A. P. Rowe (Secretary)

Death Rays!

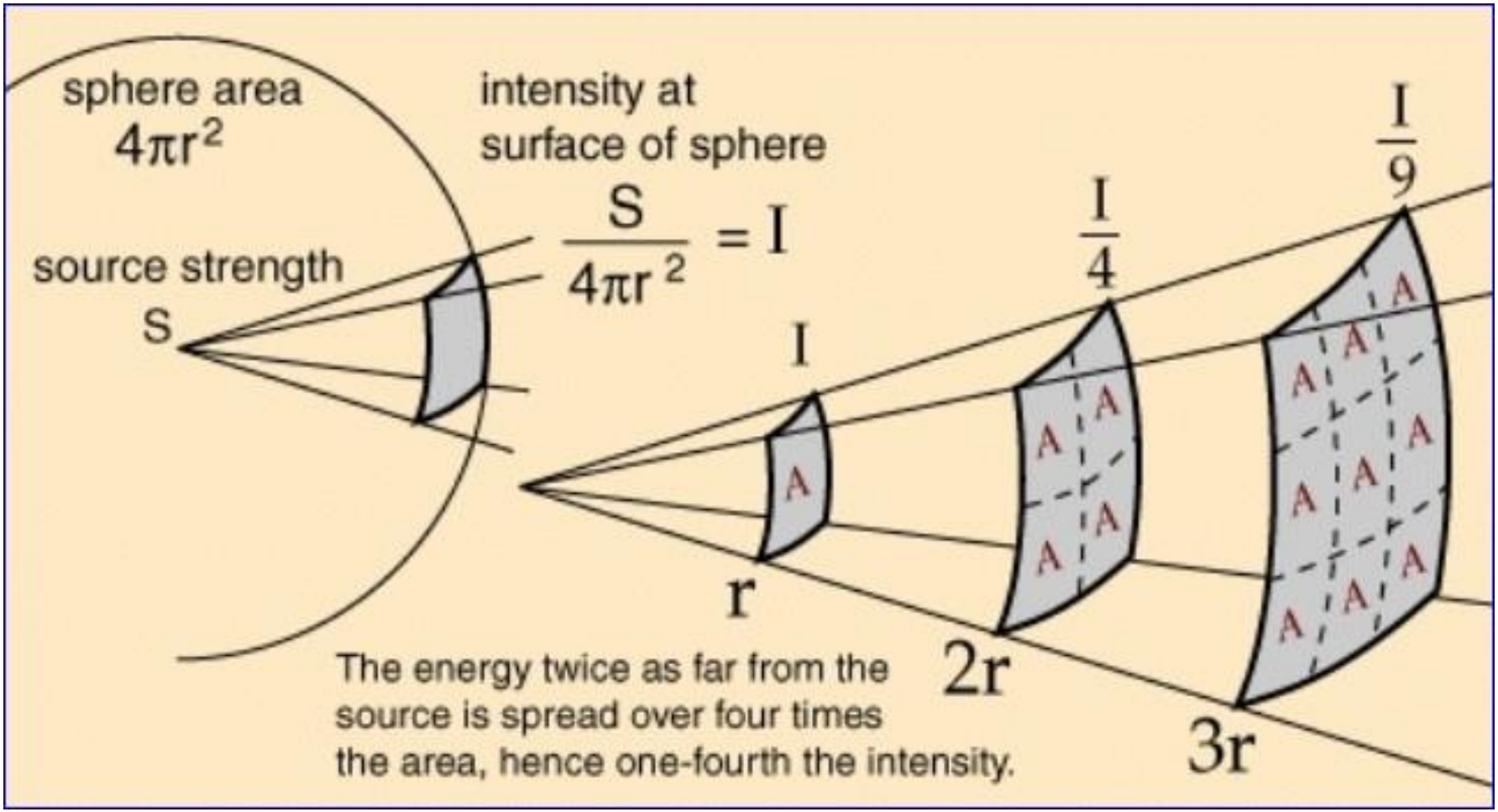
- Possibly sparked by discoveries made into radioactivity, Death Rays became a popular weapon in science fiction in the 1920s and 30s.
- Investigating one possibility, Wimperis asked Dr. Robert Watson Watt if it would be possible to concentrate a beam of radio energy so that it might incapacitate a pilot or his airplane – in effect, a death ray!

Sir Robert Watson-Watt

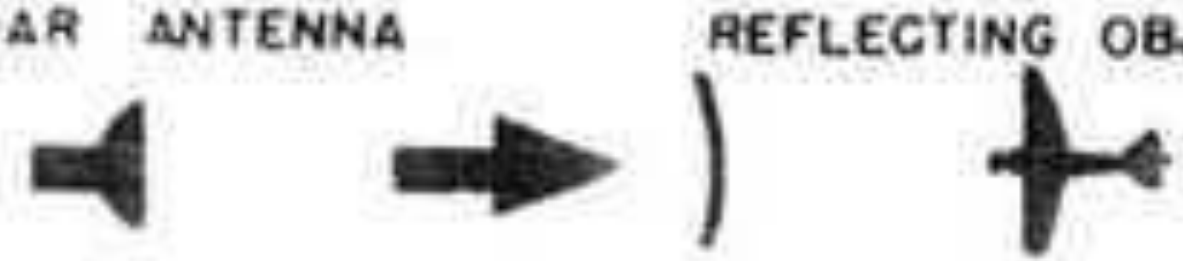





KX
50


sphere area
$4\pi r^2$
intensity at
surface of sphere
$\frac{S}{4\pi r^2} = I$
source strength
S
I
$\frac{I}{4}$
$\frac{I}{9}$
A
r
2r
3r
The energy twice as far from the source is spread over four times the area, hence one-fourth the intensity.

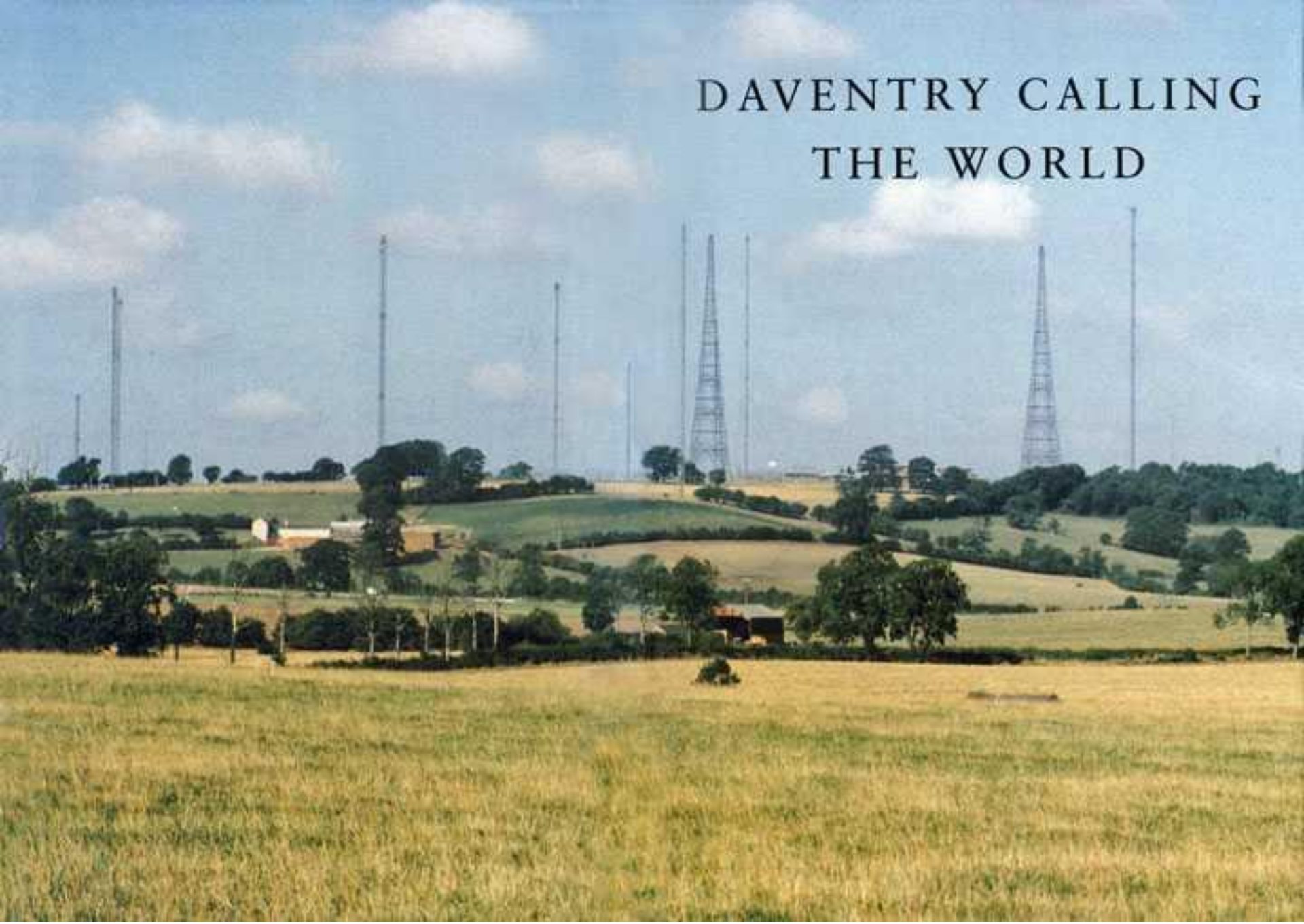
HOW RADAR PULSE IS SENT AND RECEIVED

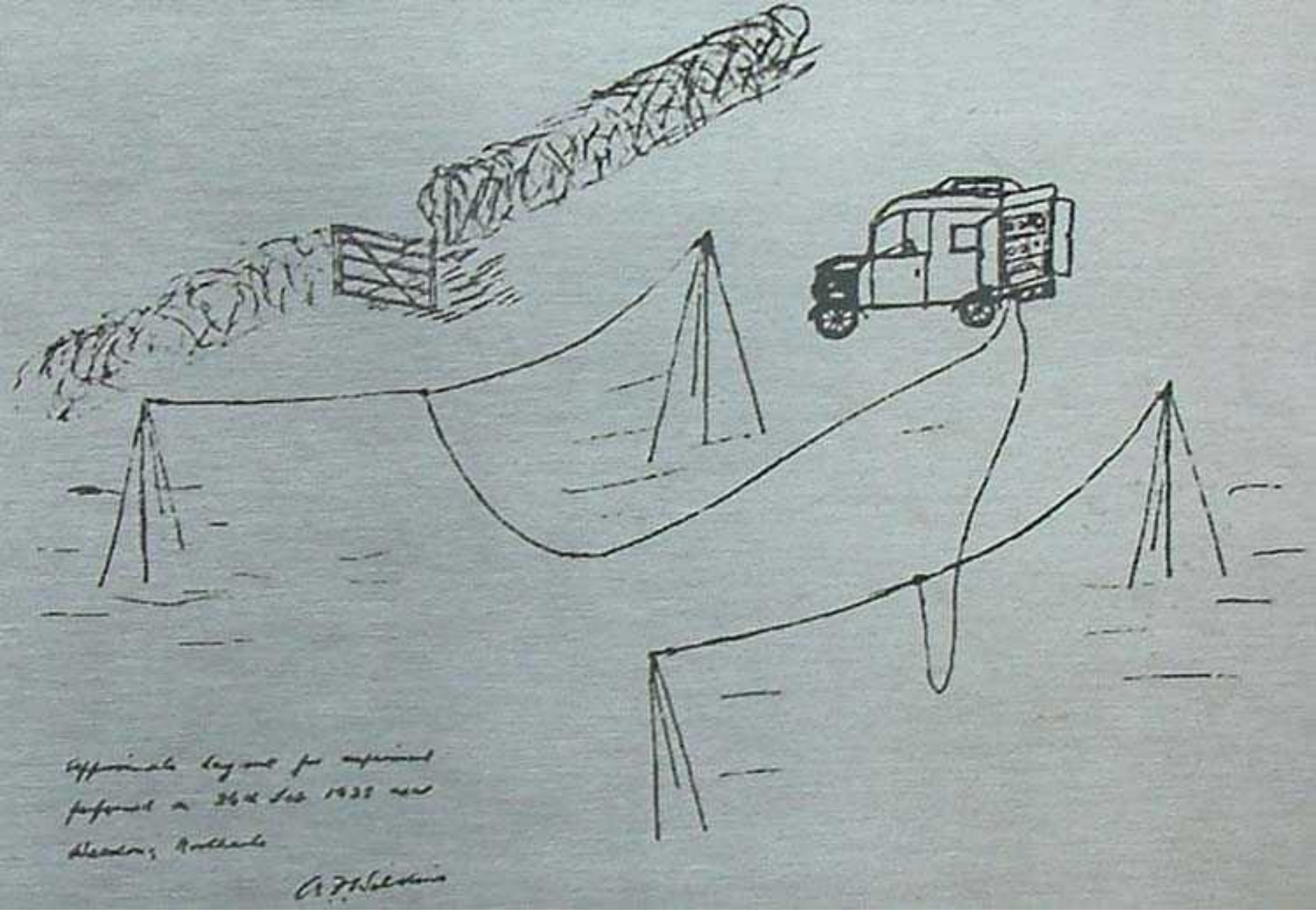


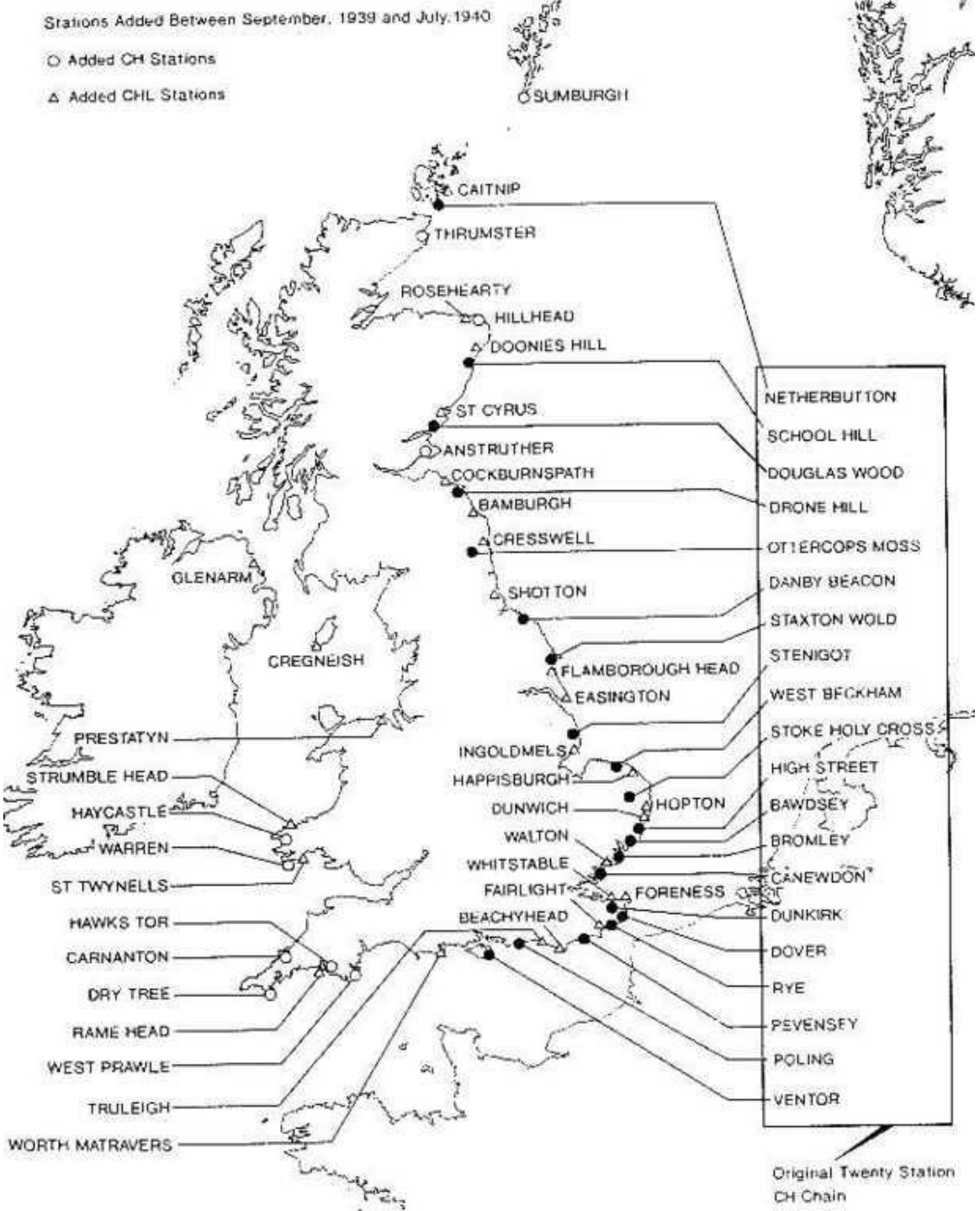
TRANSMITTED PULSE

RETURNING ECHO

IF REFLECTING OBJECT IS A MILE AWAY, THE COMPLETE OUT-AND-BACK CYCLE IS ACCOMPLISHED IN 10 MILLIONTHS OF A SECOND


DAVENTRY CALLING
THE WORLD




Stations Added Between September, 1939 and July, 1940
○ Added CH Stations
△ Added CHL Stations
SUMBURGH
CAITNIP
THRUMSTER
ROSEHEARTY
HILLHEAD
DOONIES HILL
ST CYRUS
ANSTRUTHER
COCKBURNSPATH
BAMBURGH
CRESSWELL
SHOTTON
FLAMBOROUGH HEAD
EASINGTON
INGOLDMELLS
HAPPISBURGH
DUNWICH
HOPTON
WALTON
WHITSTABLE
FAIRLIGHT
FORENESS
BEACHYHEAD
GLENARM
CREGNEISH
PRESTATYN
STRUMBLE HEAD
HAYCASTLE
WARREN
ST TWYNELLS
HAWKS TOR
CARNANTON
DRY TREE
RAME HEAD
WEST PRAWLE
TRULEIGH
WORTH MATRAVERS
NETHERBUTTON
SCHOOL HILL
DOUGLAS WOOD
DRONE HILL
OTTERCOPS MOSS
DANBY BEACON
STAXTON WOLD
STENIGOT
WEST BECKHAM
STOKE HOLY CROSS
HIGH STREET
BAWDSEY
BROMLEY
CANEWDON
DUNKIRK
DOVER
RYE
PEVENSEY
POLING
VENTOR
Original Twenty Station
CH Chain


Bawdsey Manor

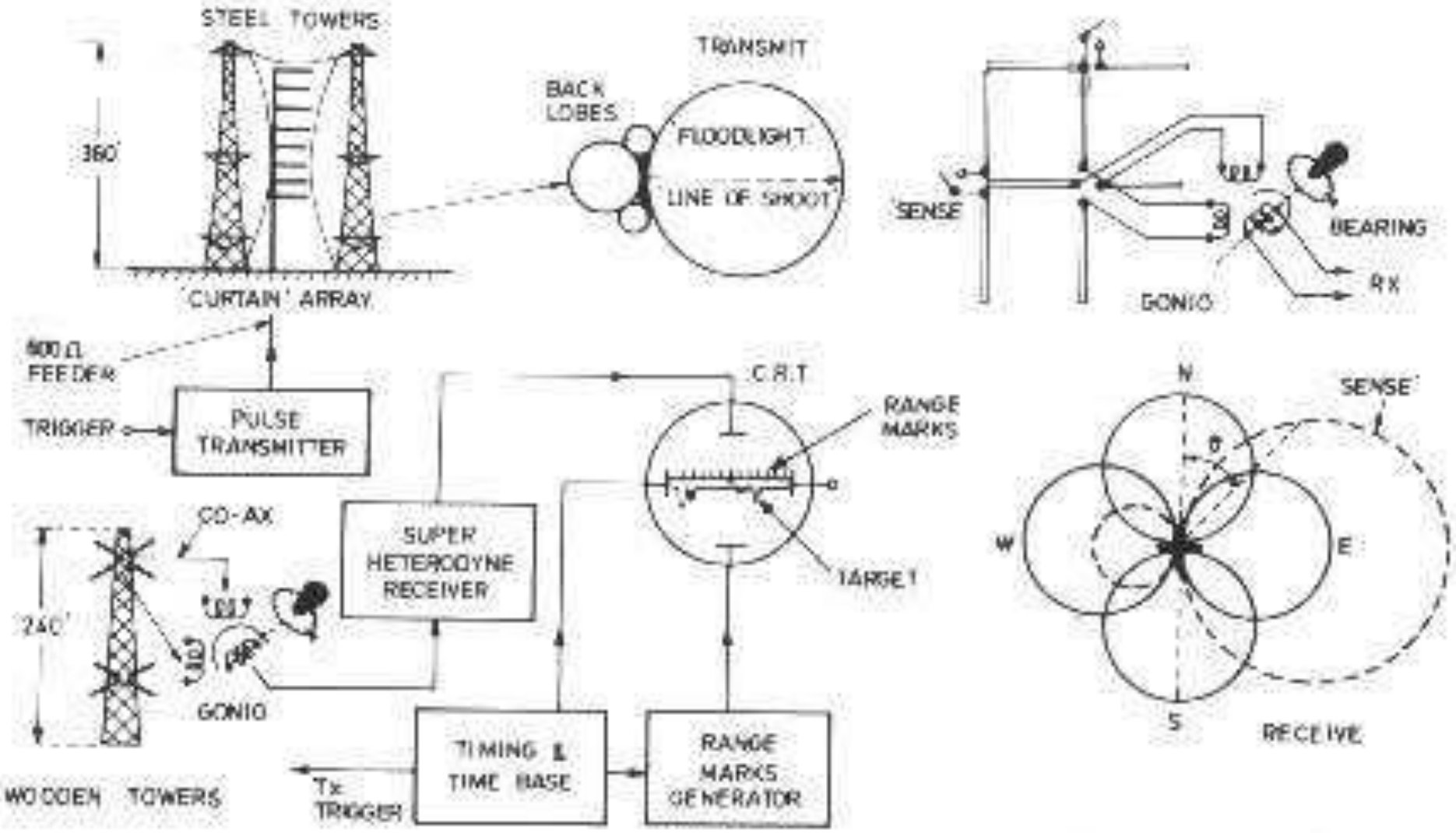
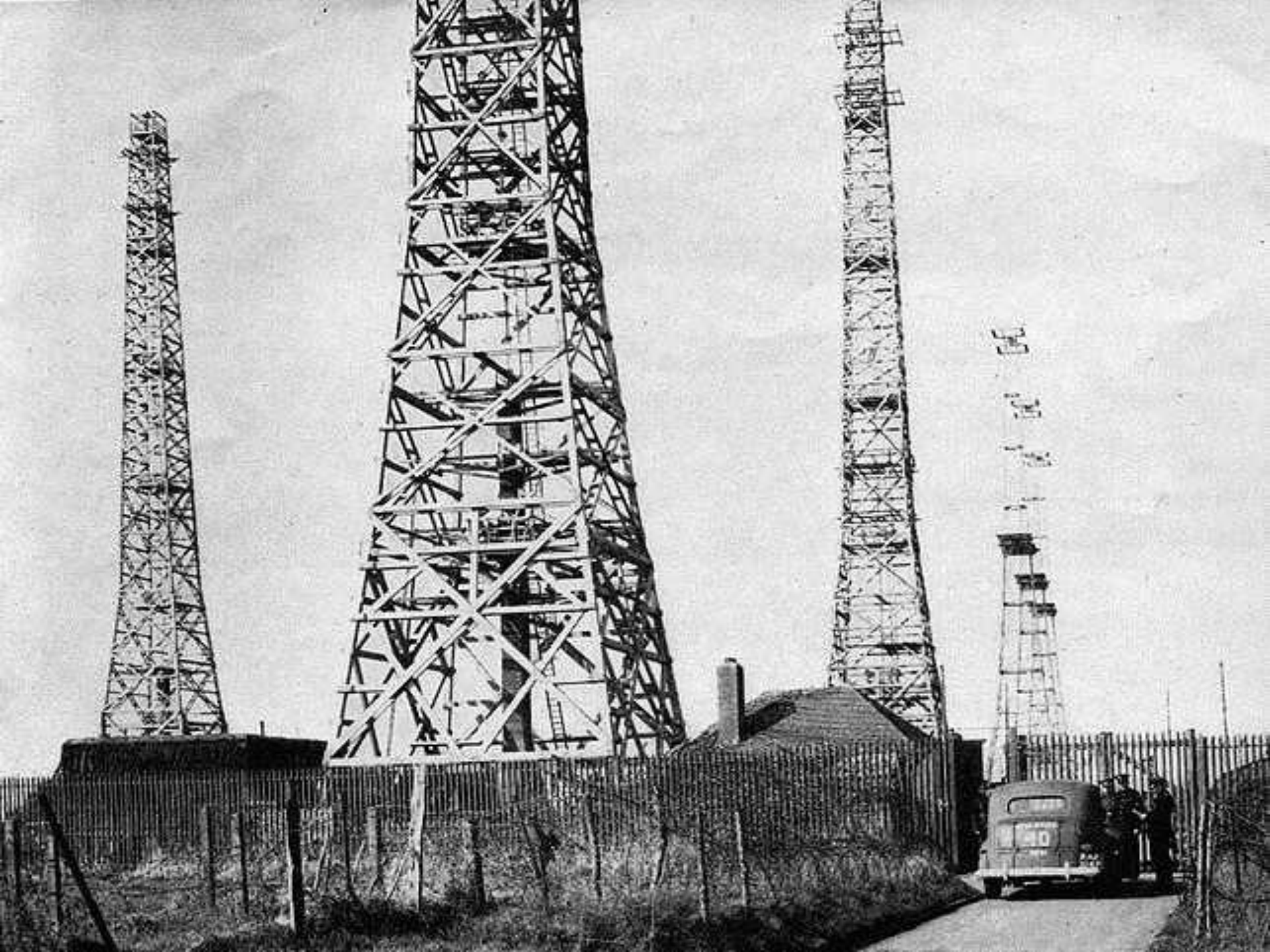


Fig. 1. Principles of CH (Chain Home) R.D.F. system



Operating Parameters

- Frequency: 20 to 30 MHz
- Peak Power: 350 kW (later 750 kW)
- Pulse Repetition Frequency: 25 and 12.5 pulses per second
- Pulse Length: 20 microseconds

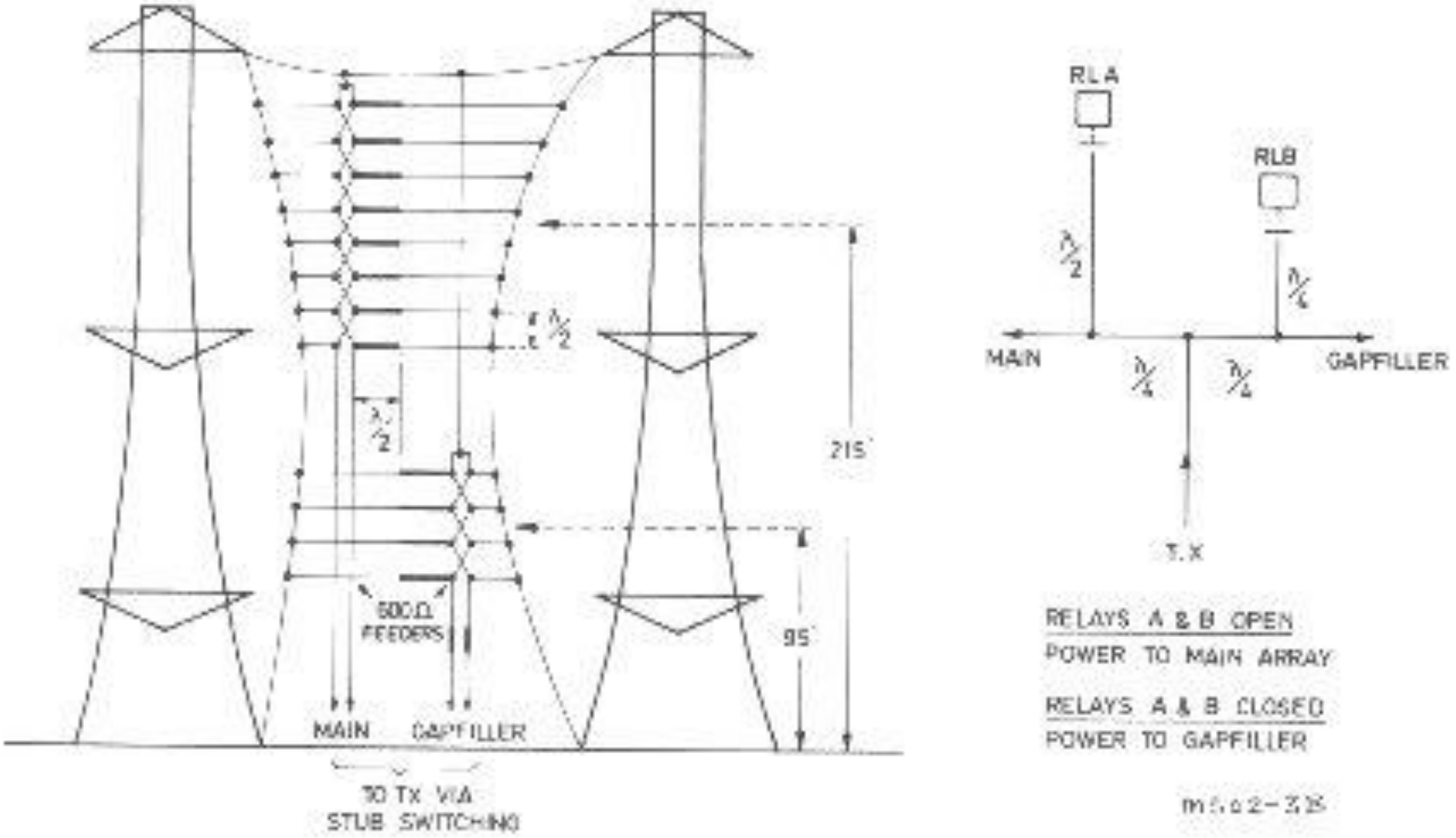
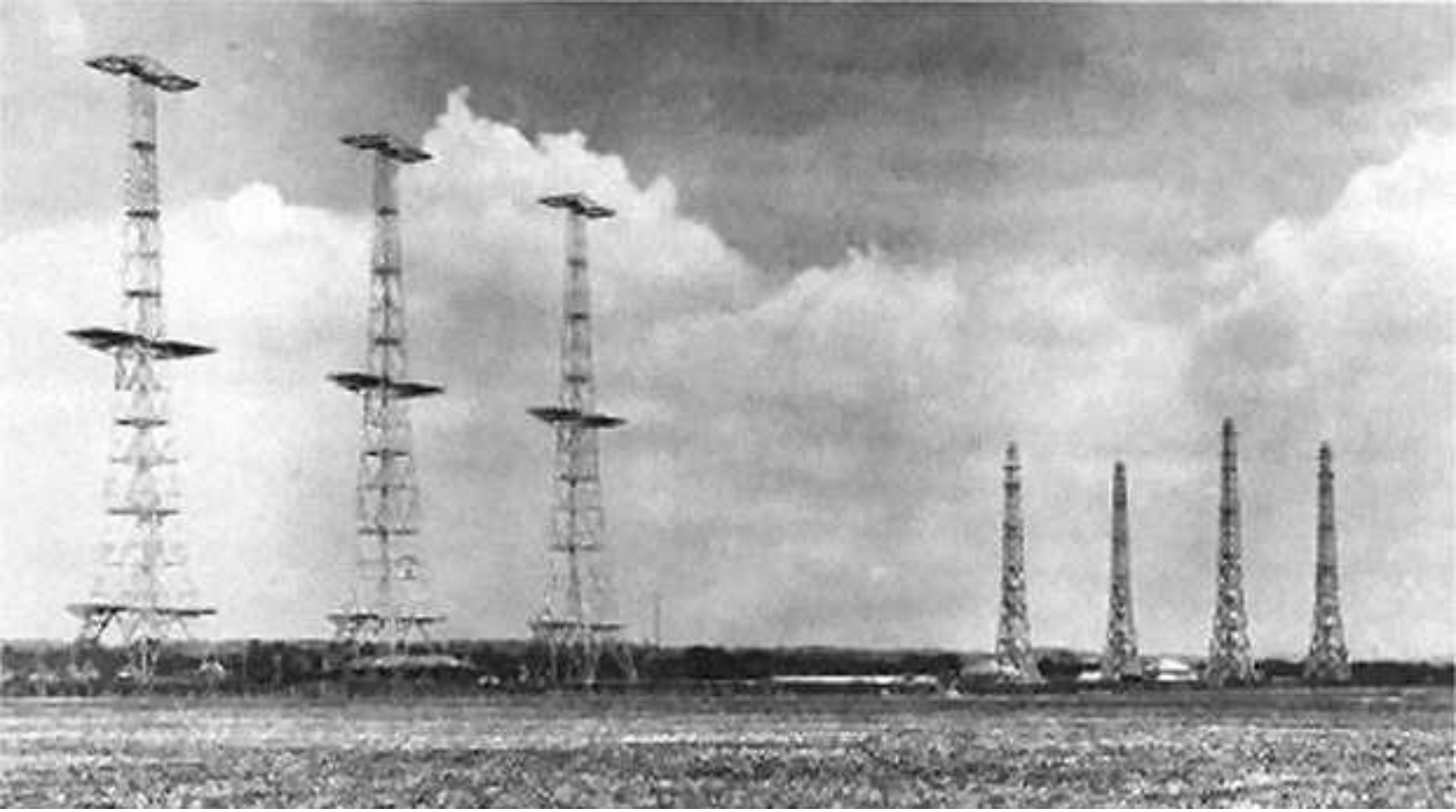
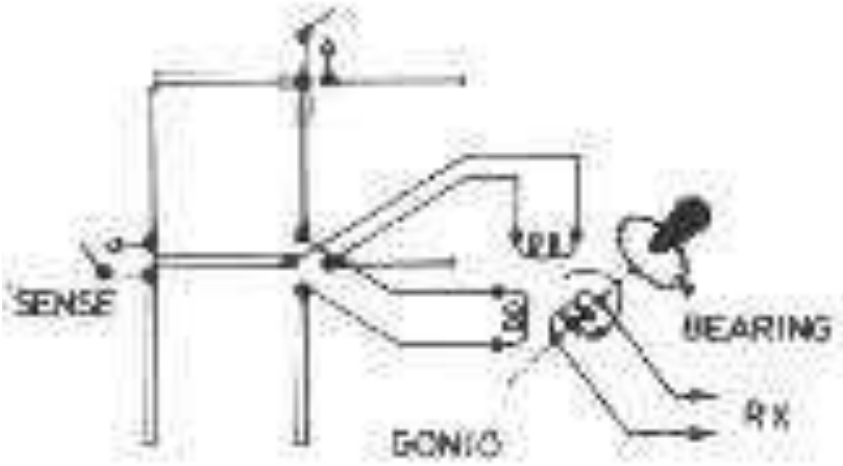
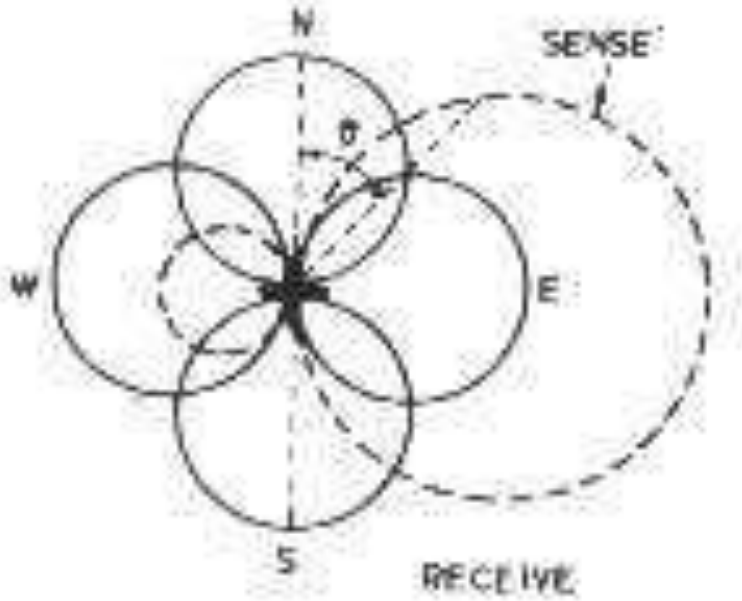


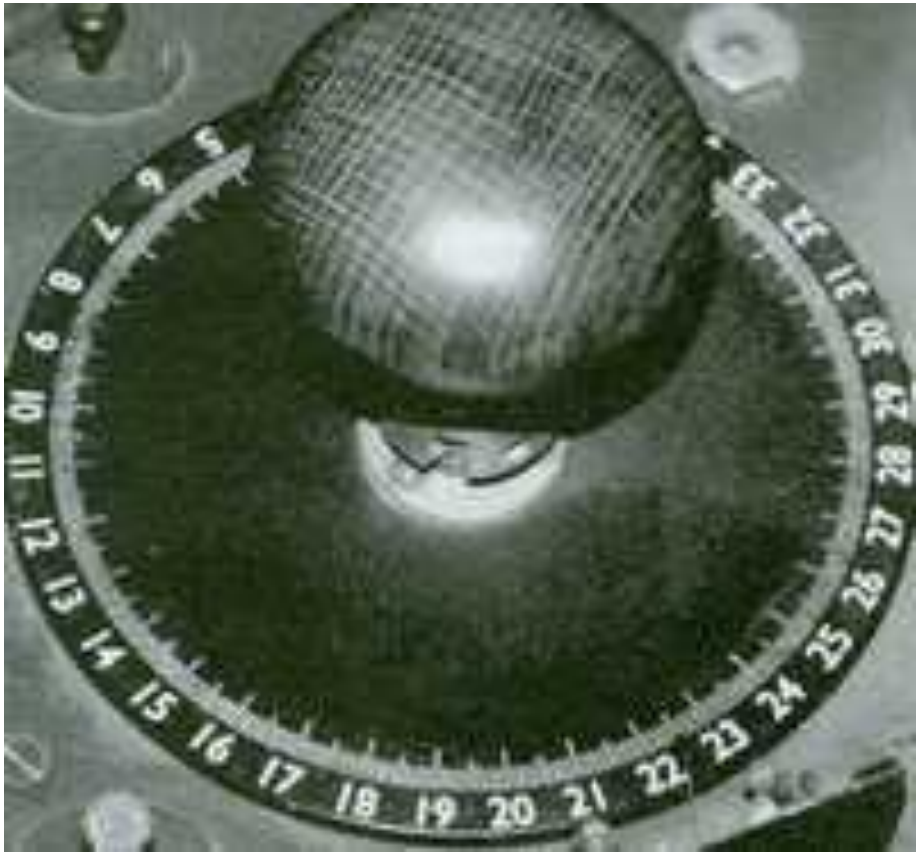
Fig. 3. (a) CH transmitter array (b) stub switching







Determining Direction


5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

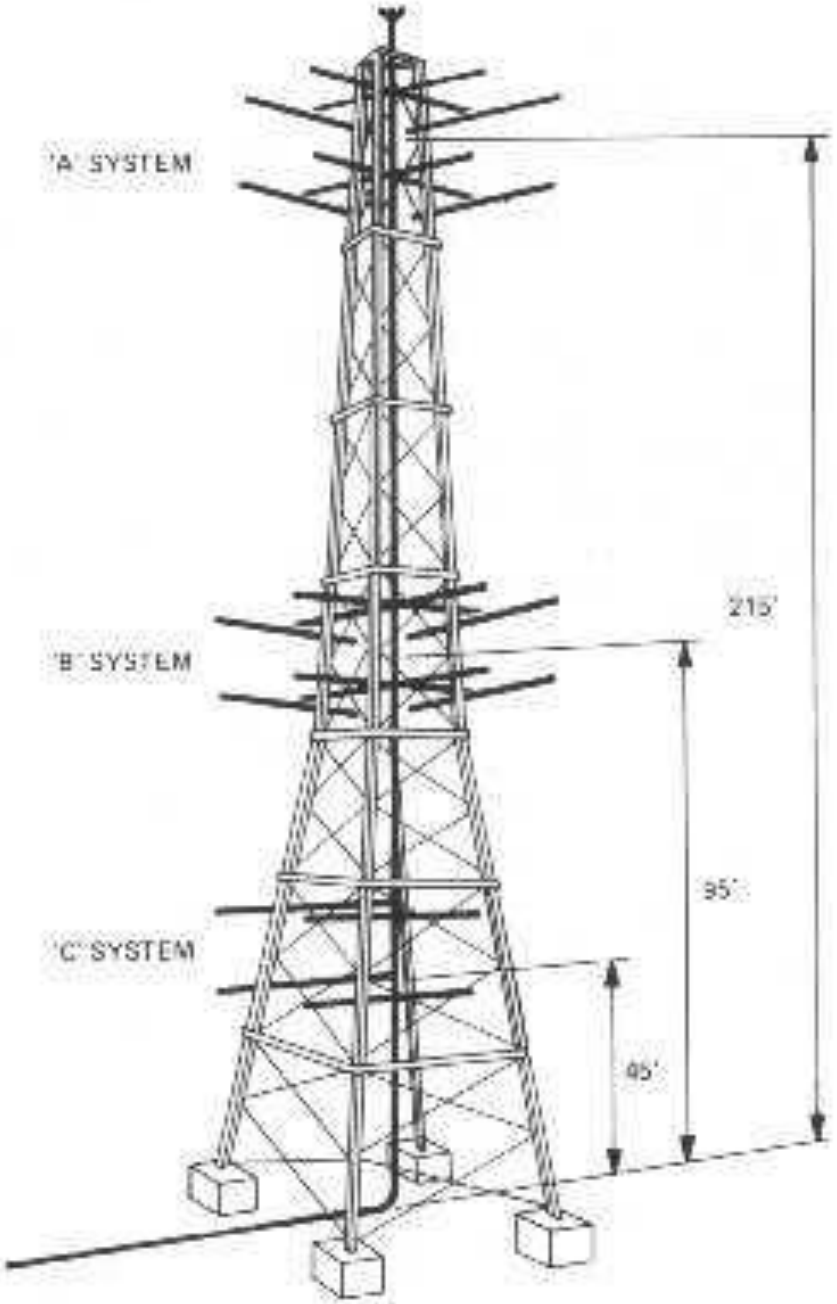


Fig. 8. Dipole arrays on a receiver lower

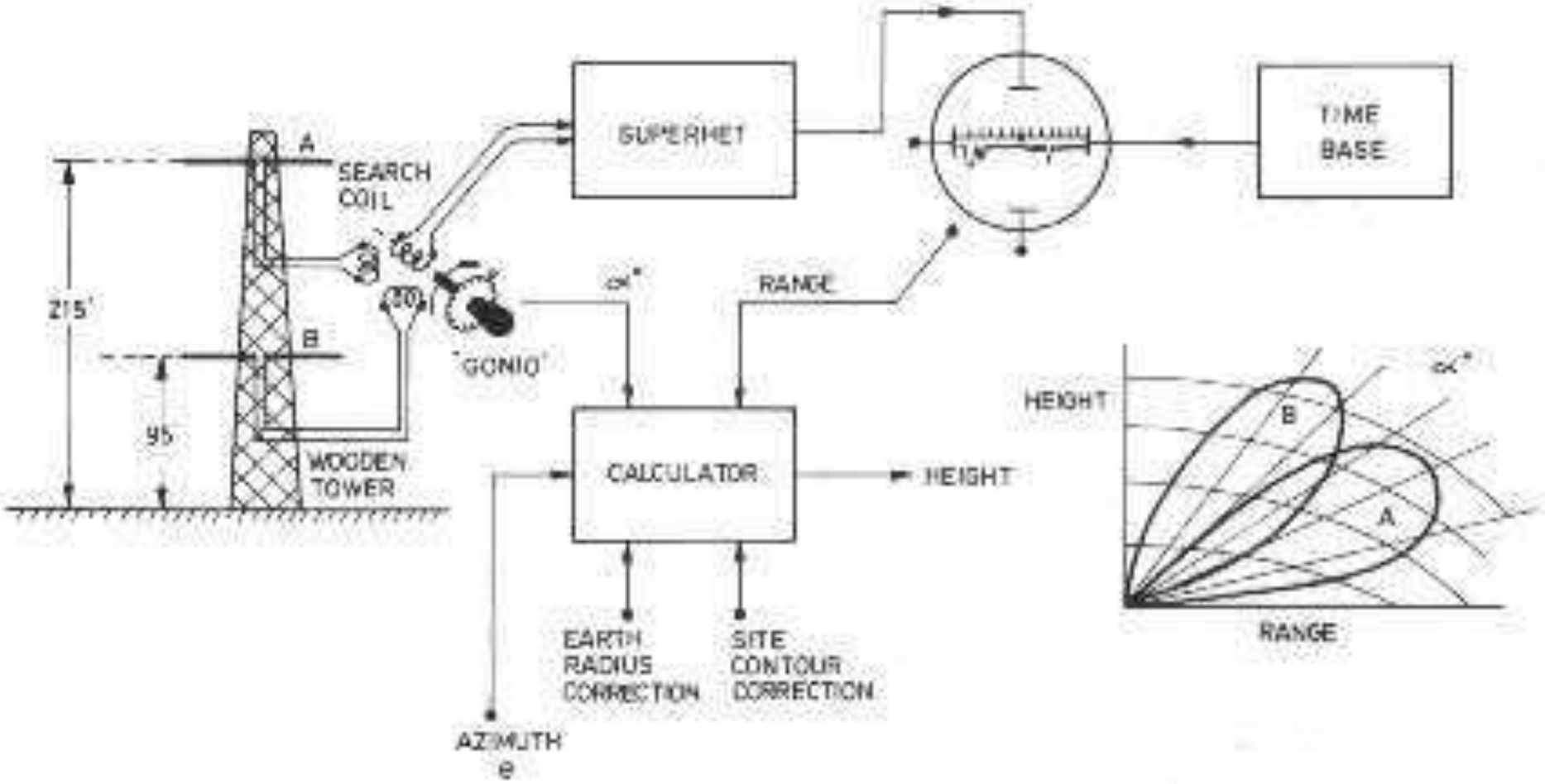


Fig. 4. The principles of CH height-finding

Cierva Autogiro

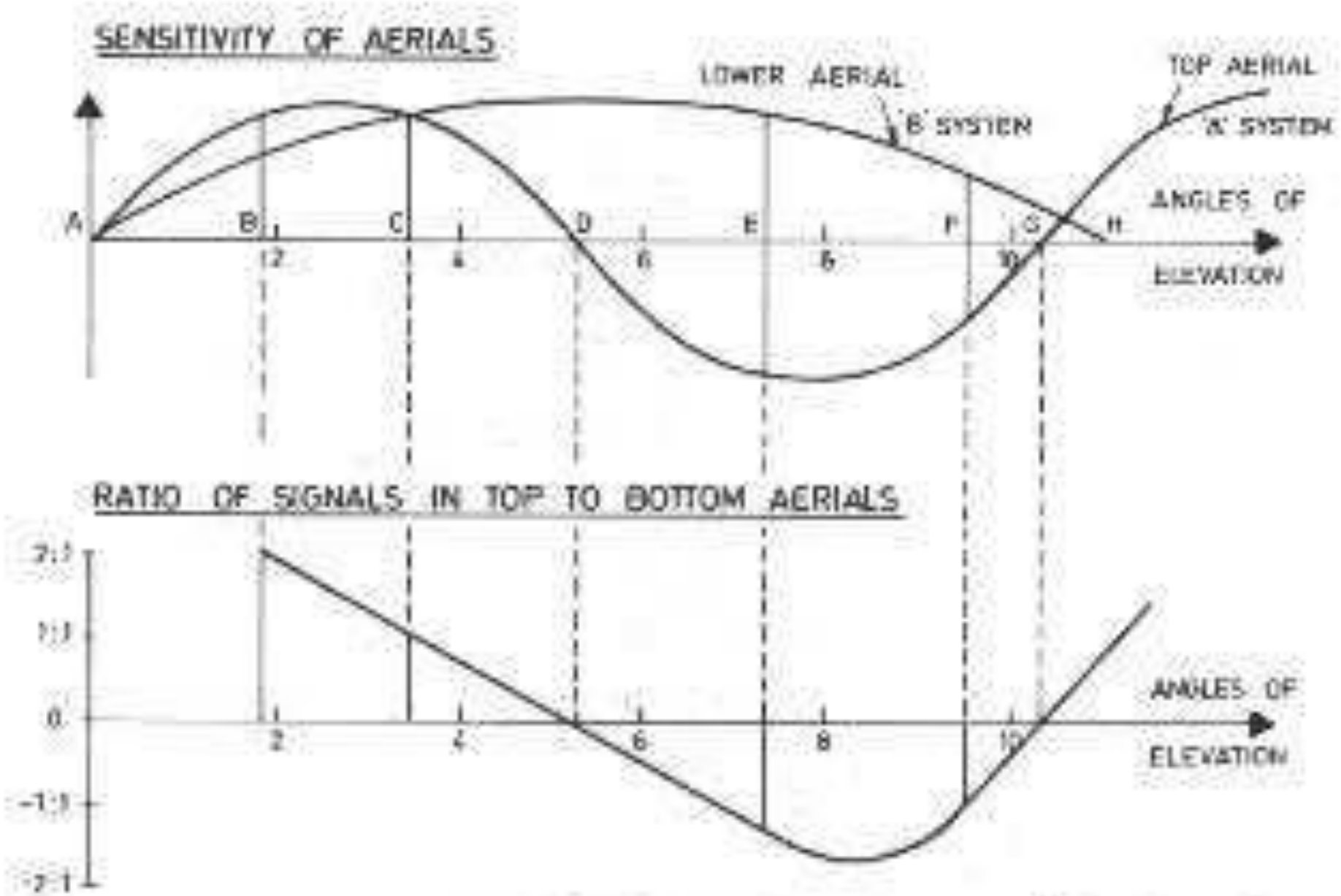


Fig. 5. Signals on height-finding dipoles, and their ratio

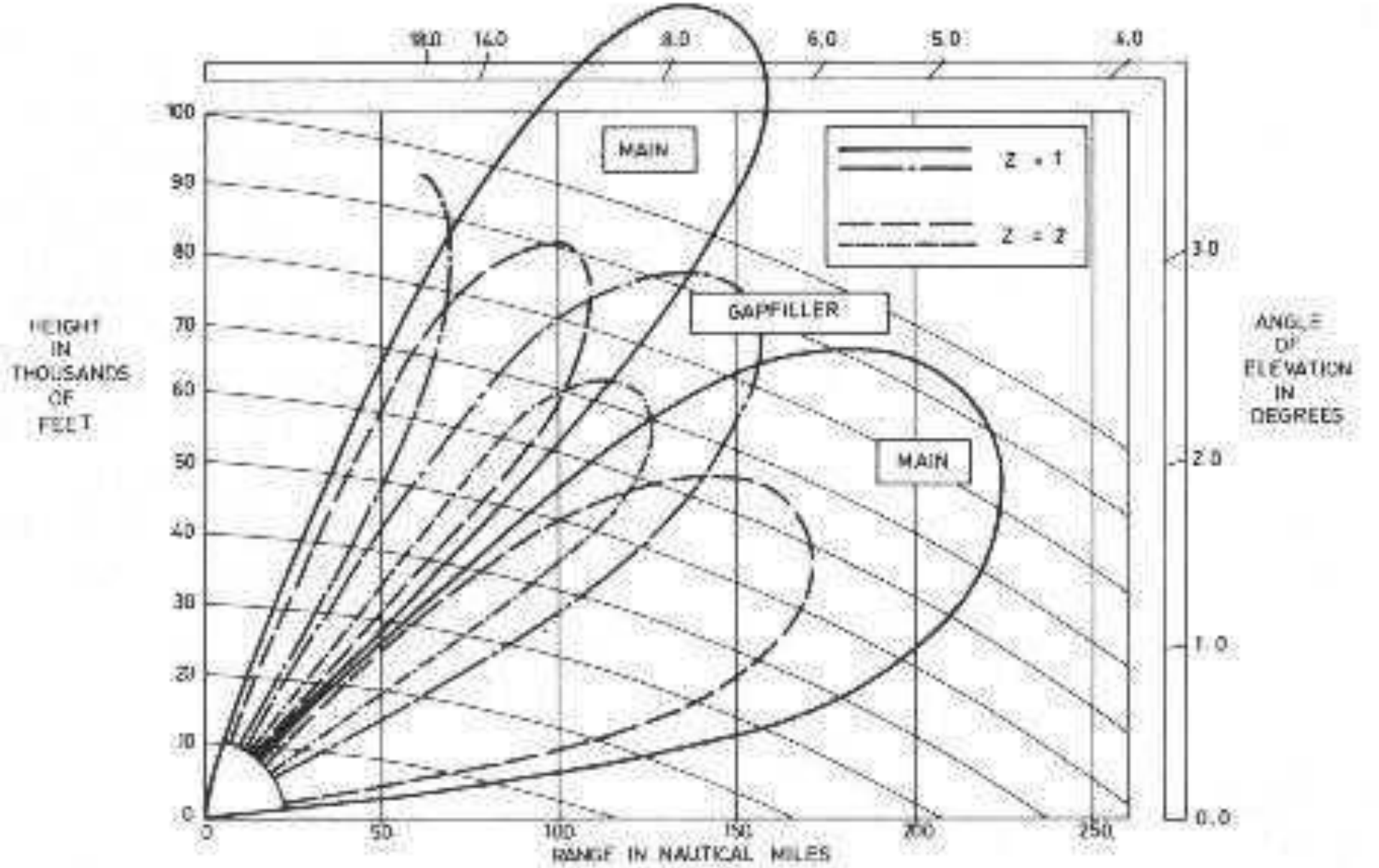
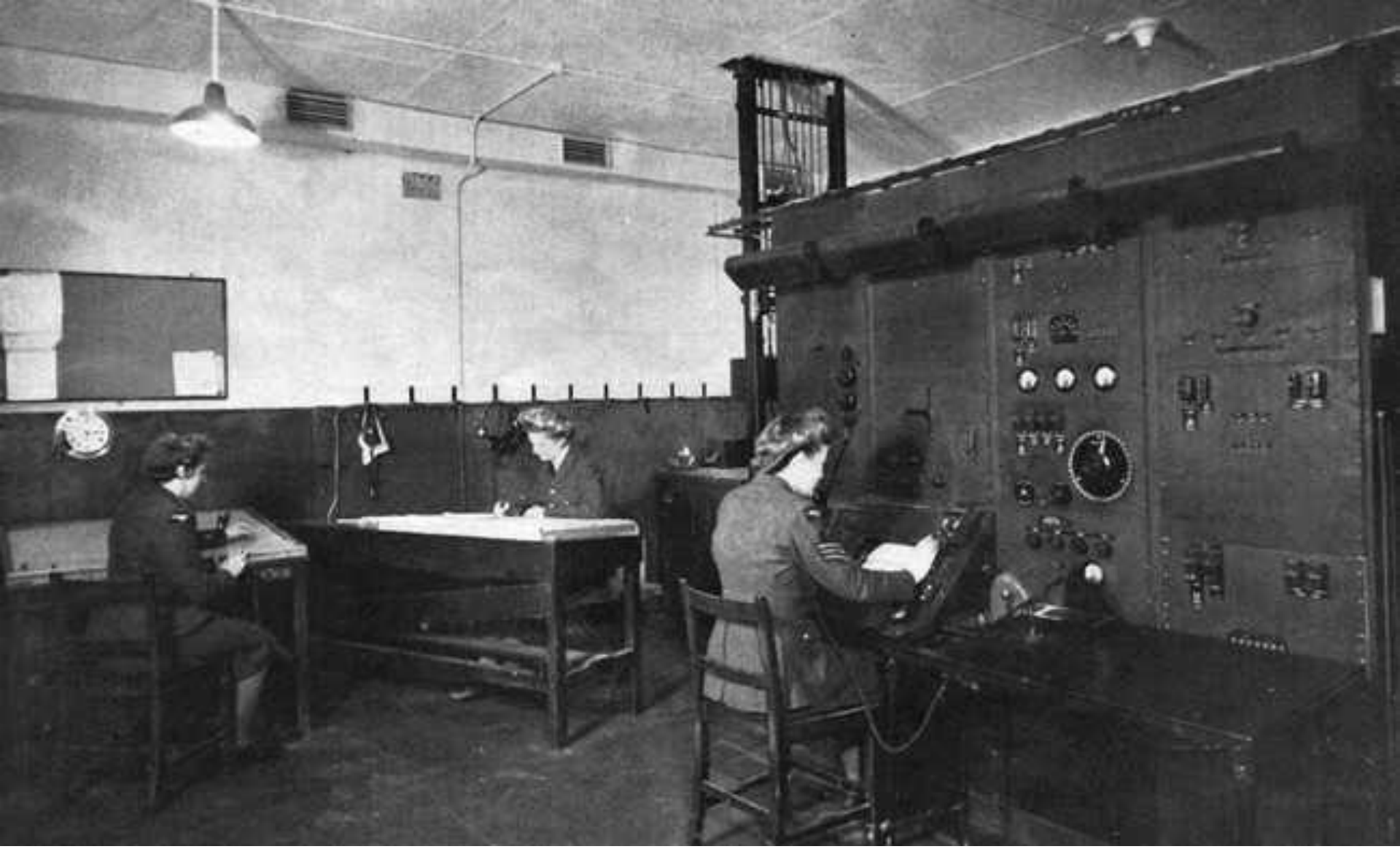


Fig. 6. Typical CH performance diagram



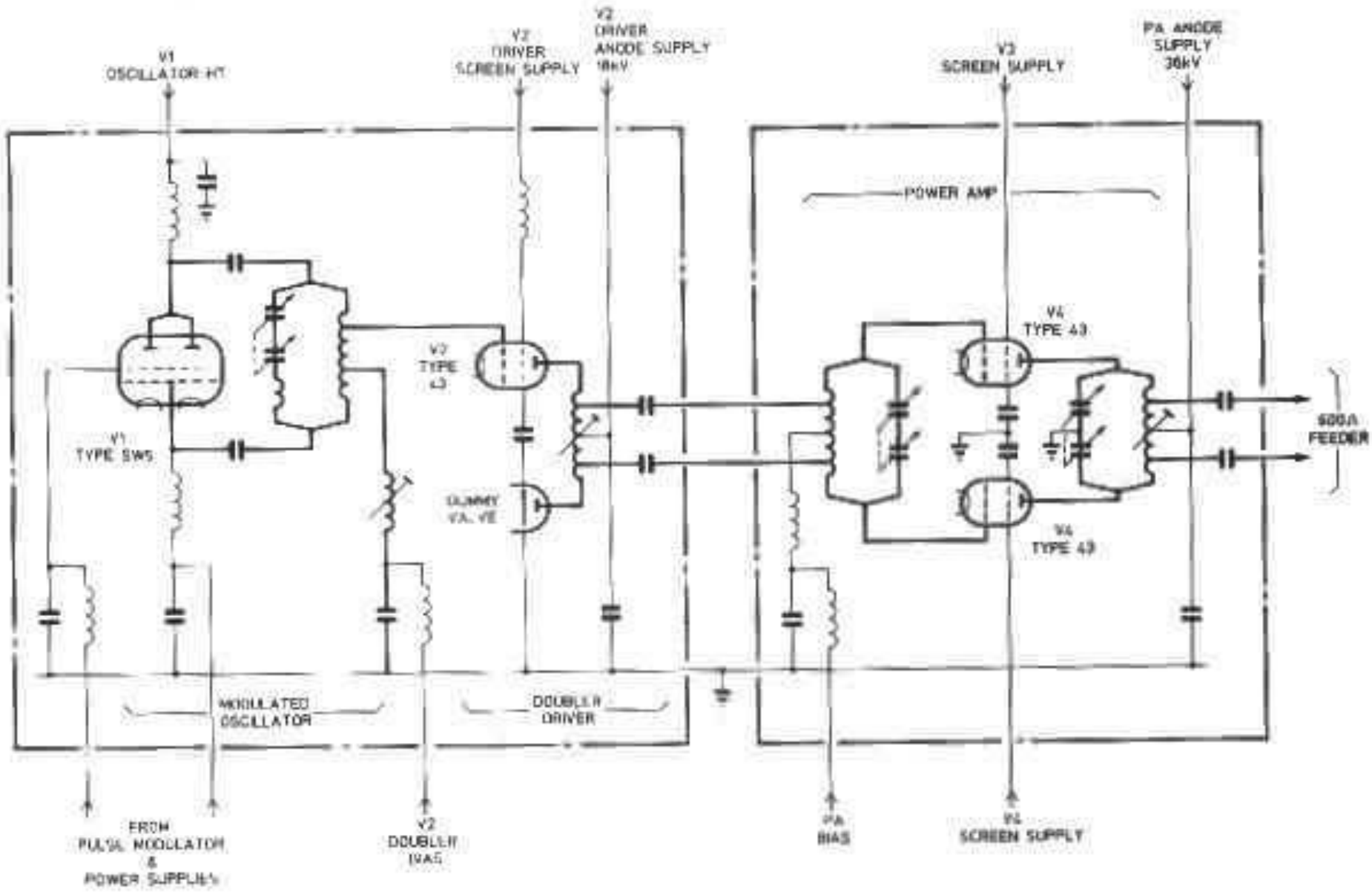


Fig. 10. Simplified circuit diagram of CH transmitter

Fig. 9. East Coast CH transmitter room

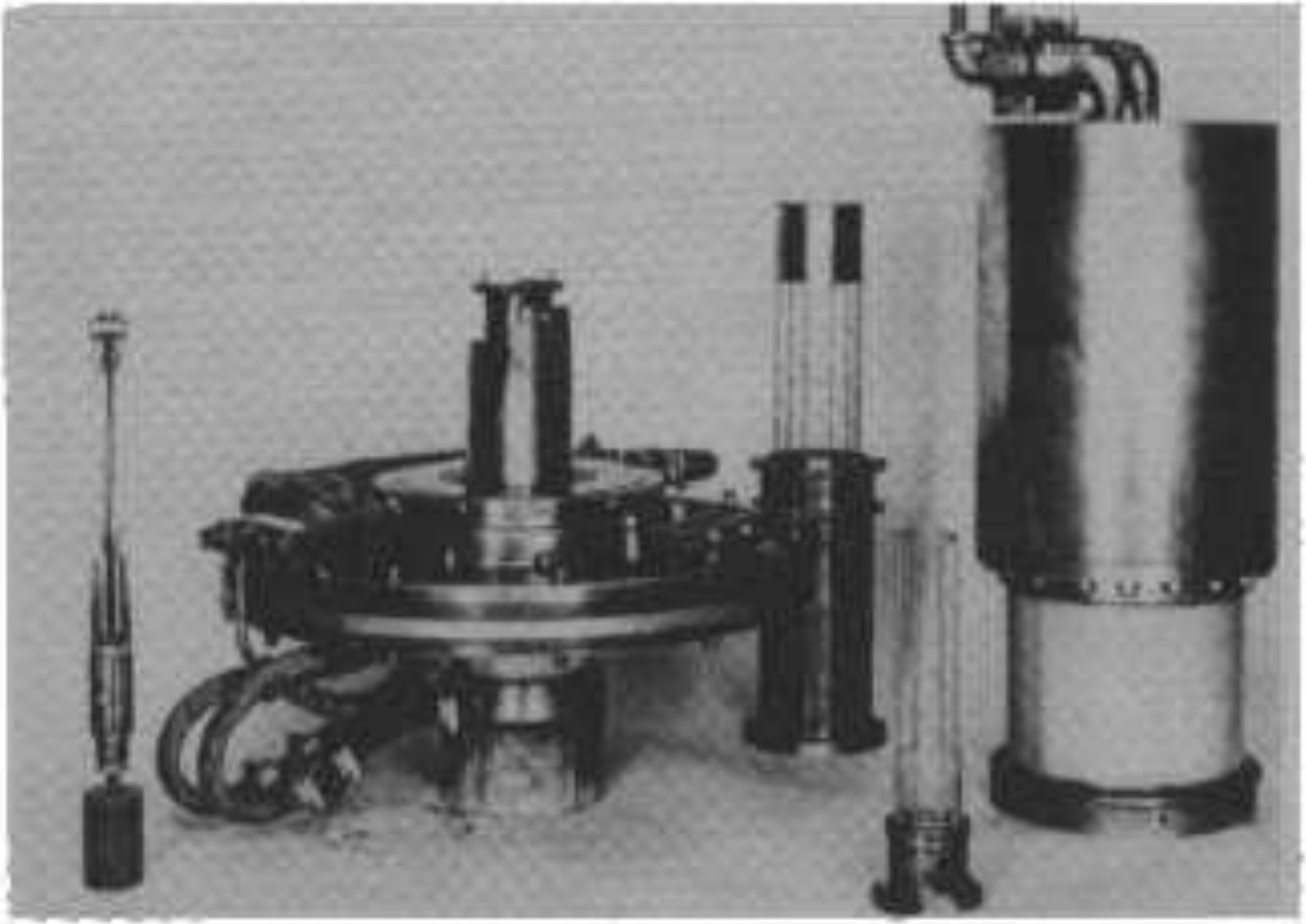


Fig. 11. Components of demountable valve type 43

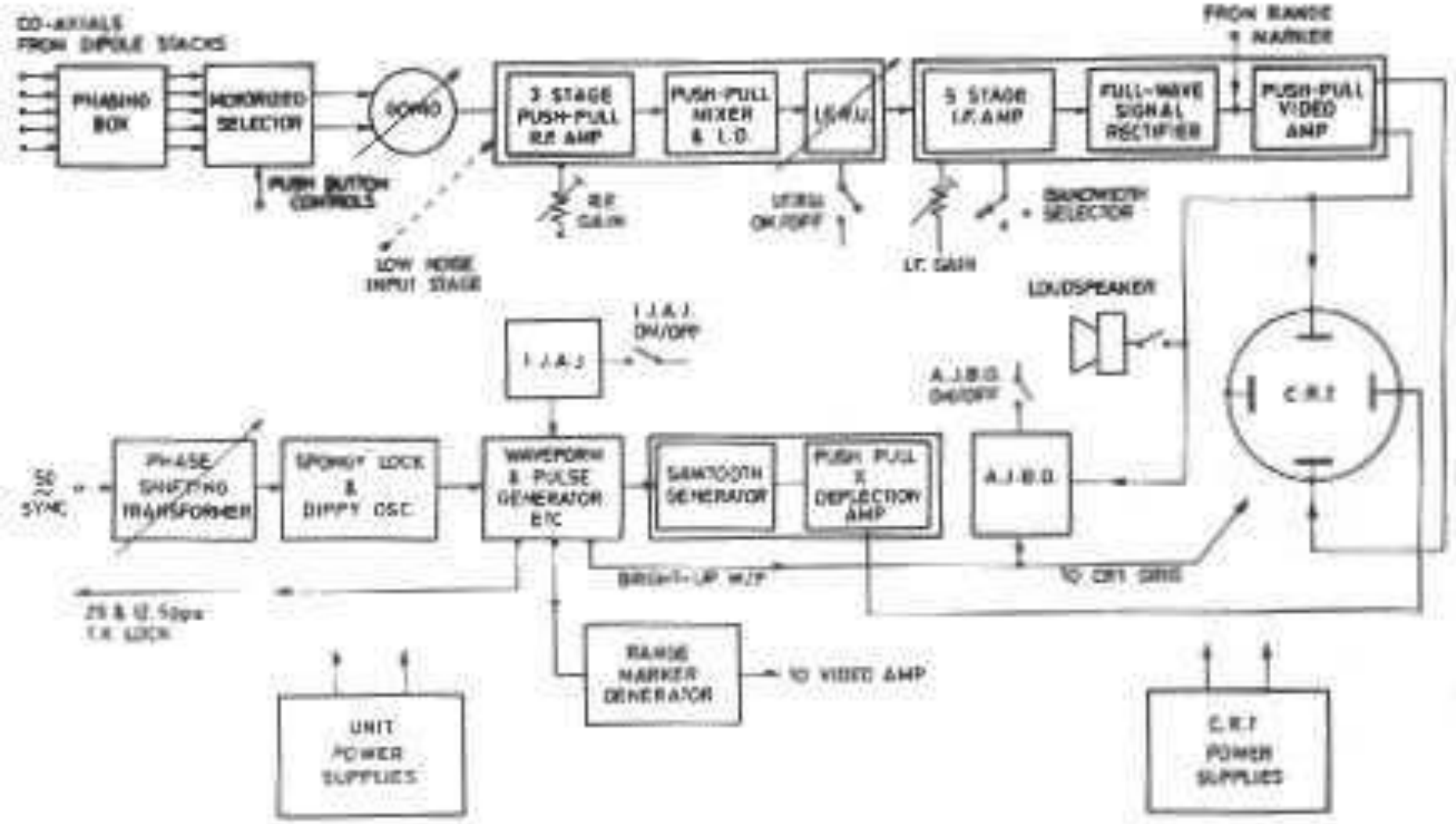


Fig. 12. Schematic diagram of receiver and display console

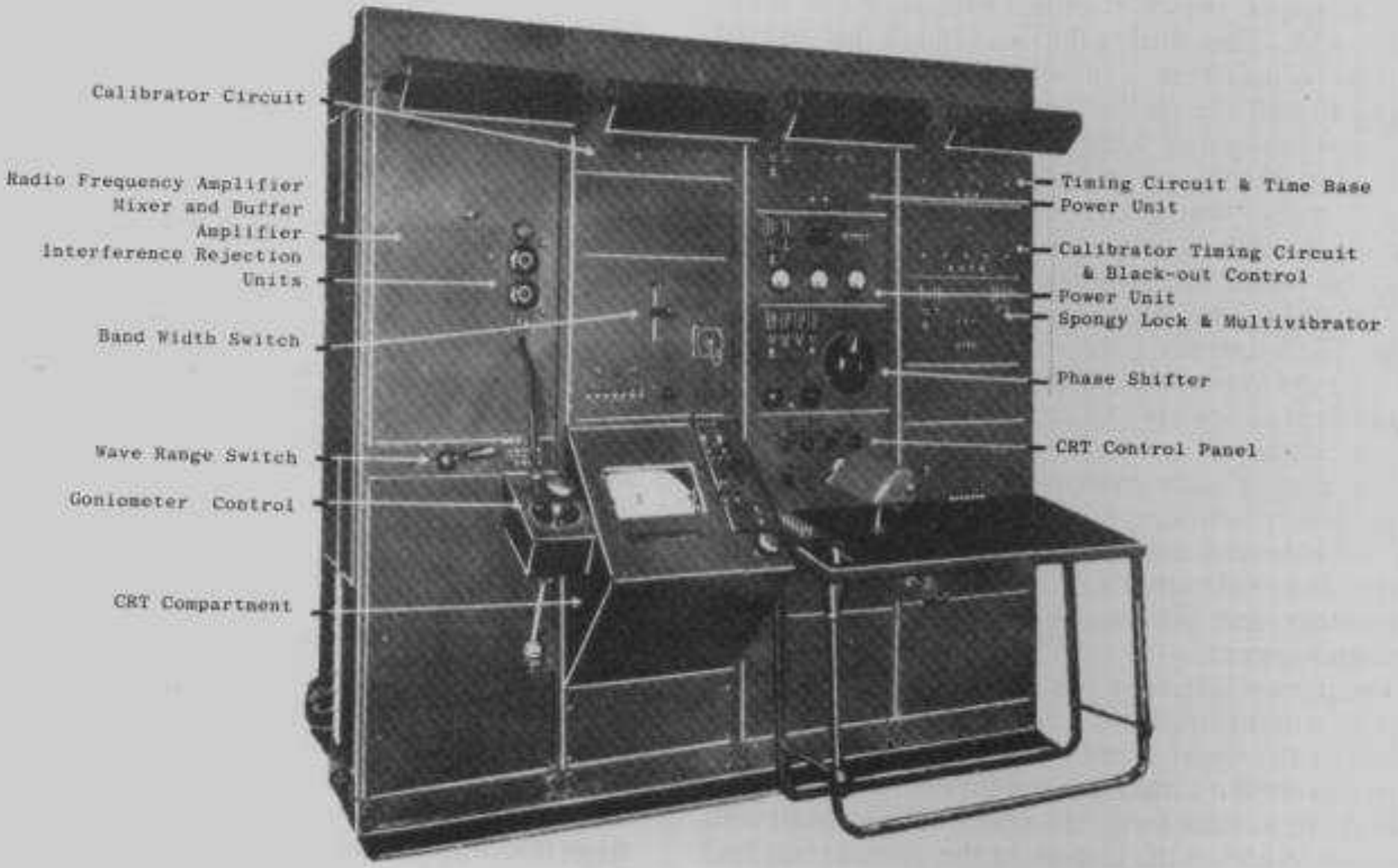


Fig. 13. East Coast receiver RF7

Fig. 14 CII receiver room

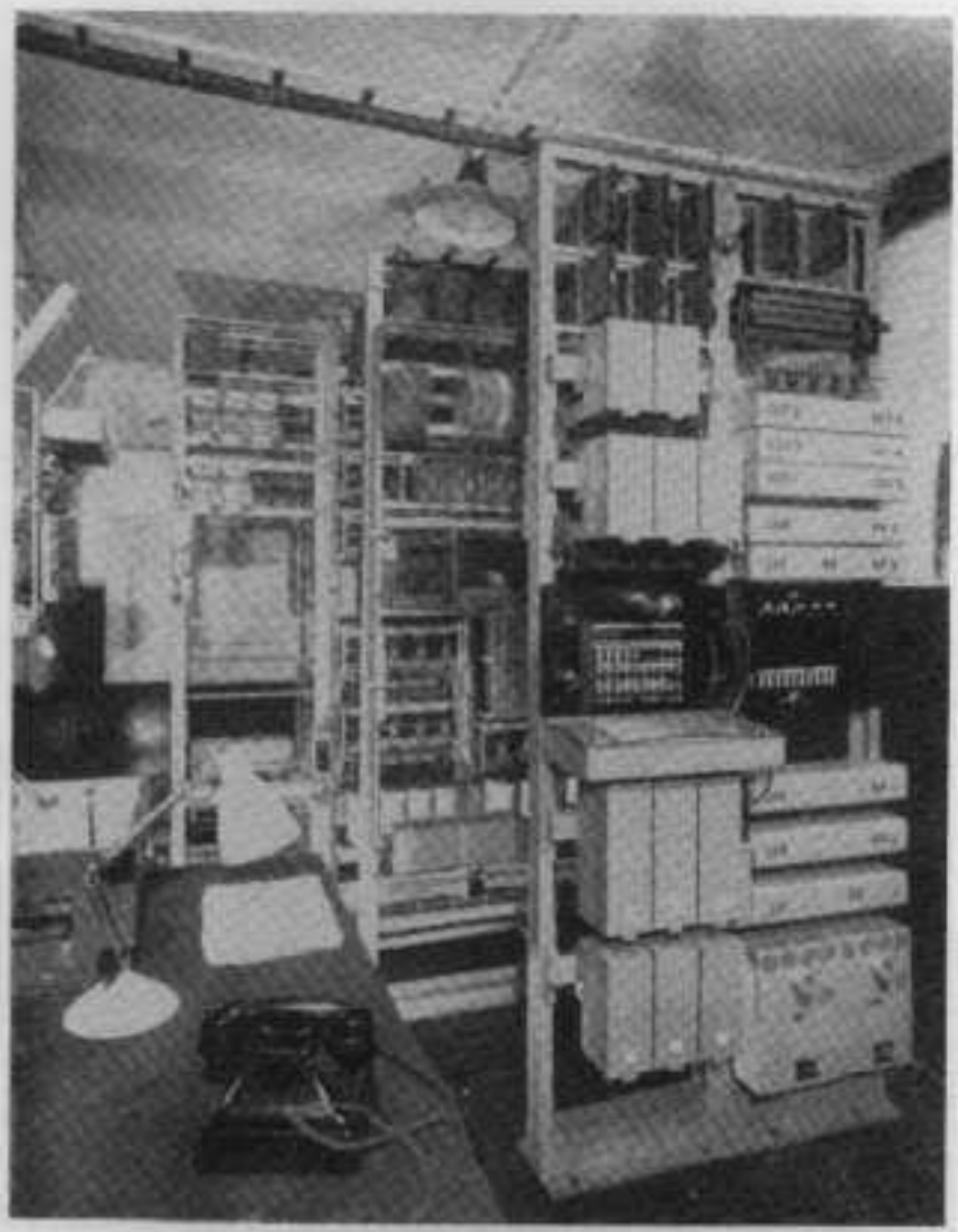
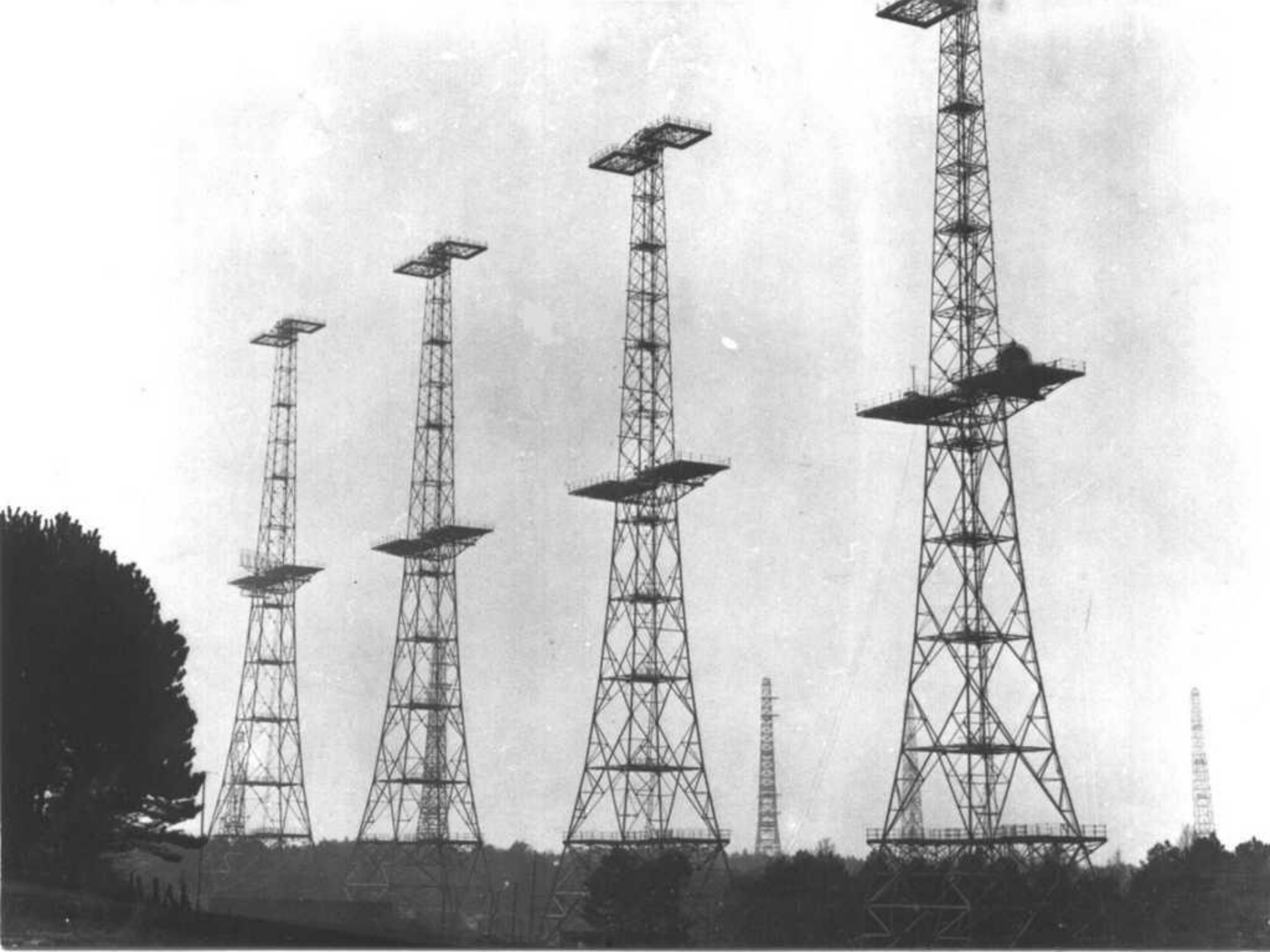
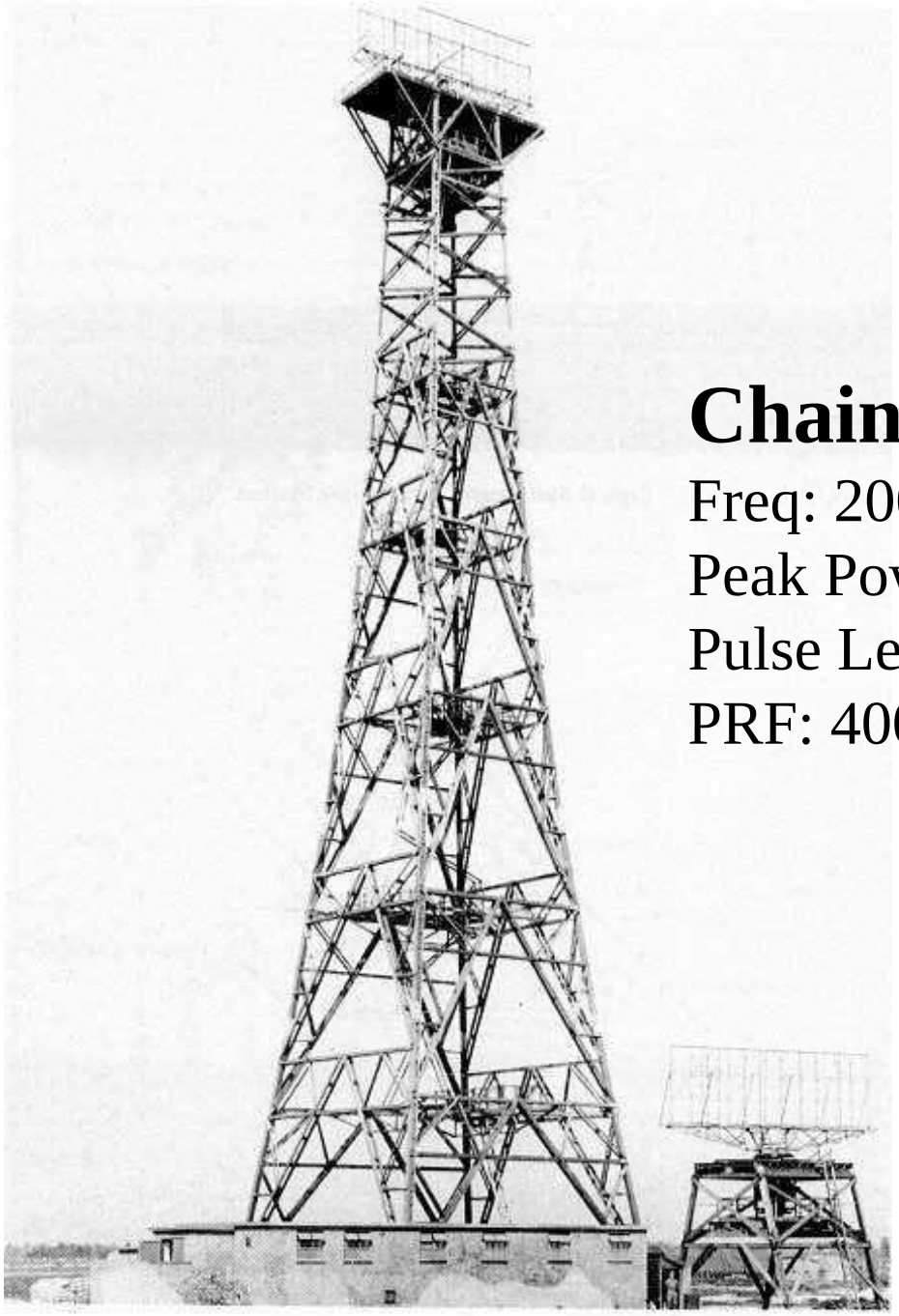


Fig. 15. CH electro-mechanical calculator





3 AMES Type 2 CHL Chain Home Low Station (185ft Tower)

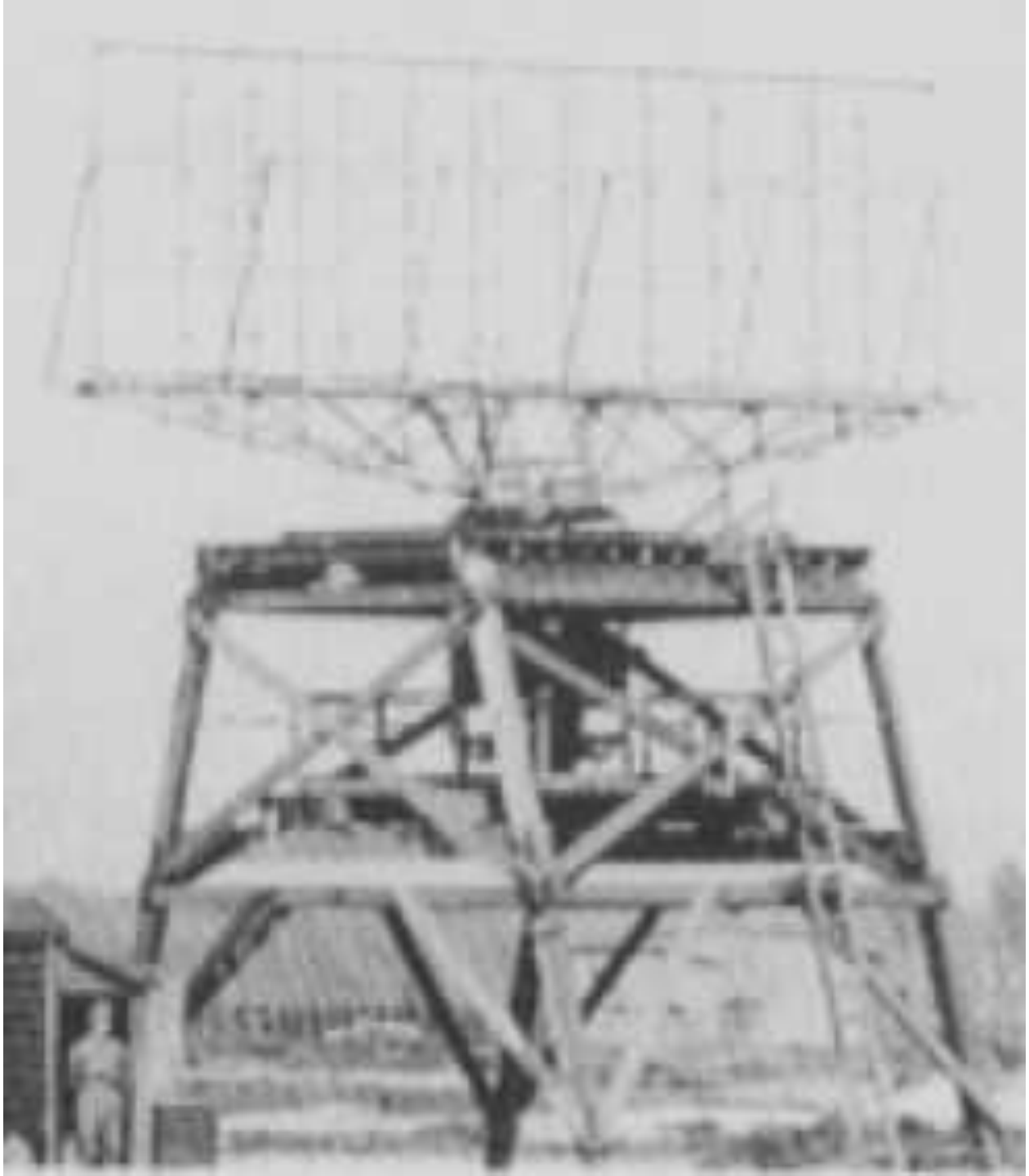
Chain Home Low

Freq: 200 MHz

Peak Power: 150 kW

Pulse Length: 3 microsec

PRF: 400 pulses per second



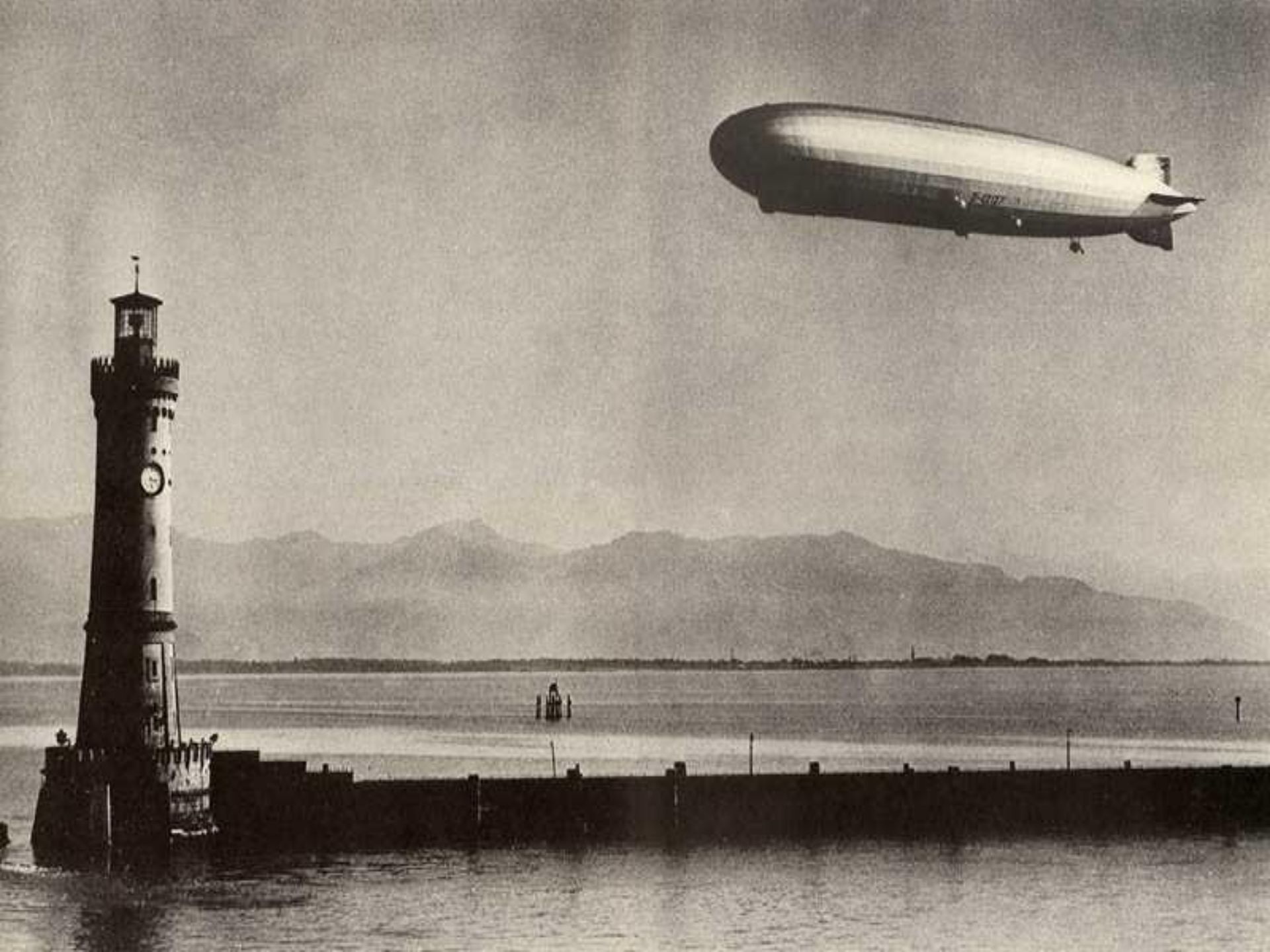
The Germans become suspicious!

- By 1939 it was pretty difficult to hide the towers dotting the British coast.
- General Wolfgang Martini, Chief of Communications for the Luftwaffe, was determined to discover their purpose!

Insert photo of General Martini

Here!

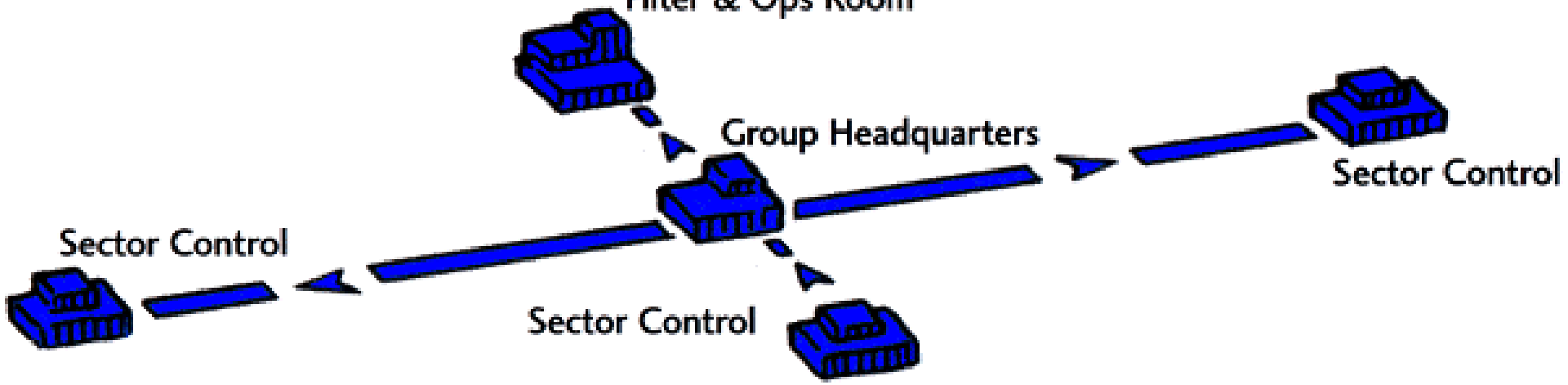
Google Images let me down!!

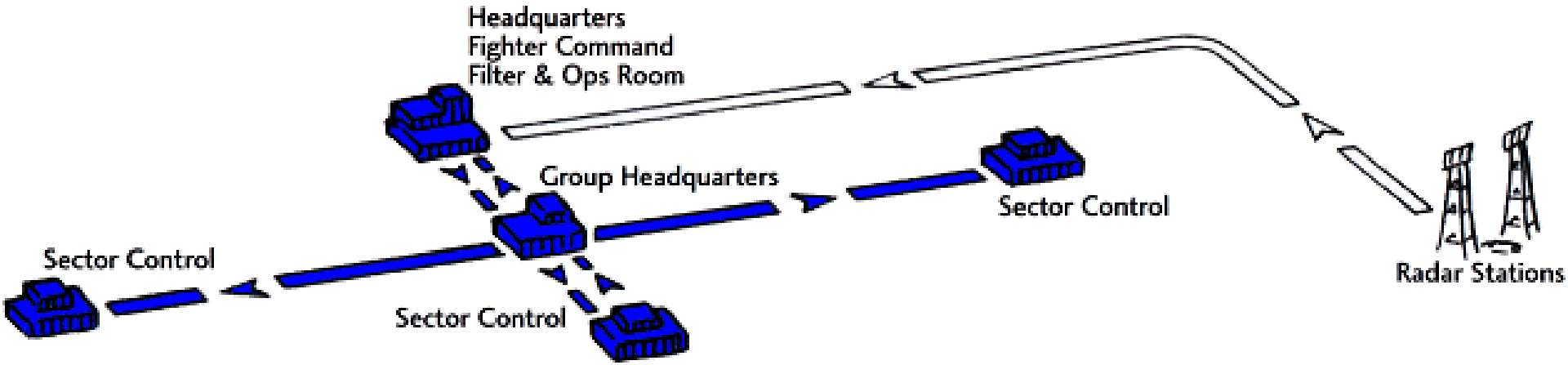


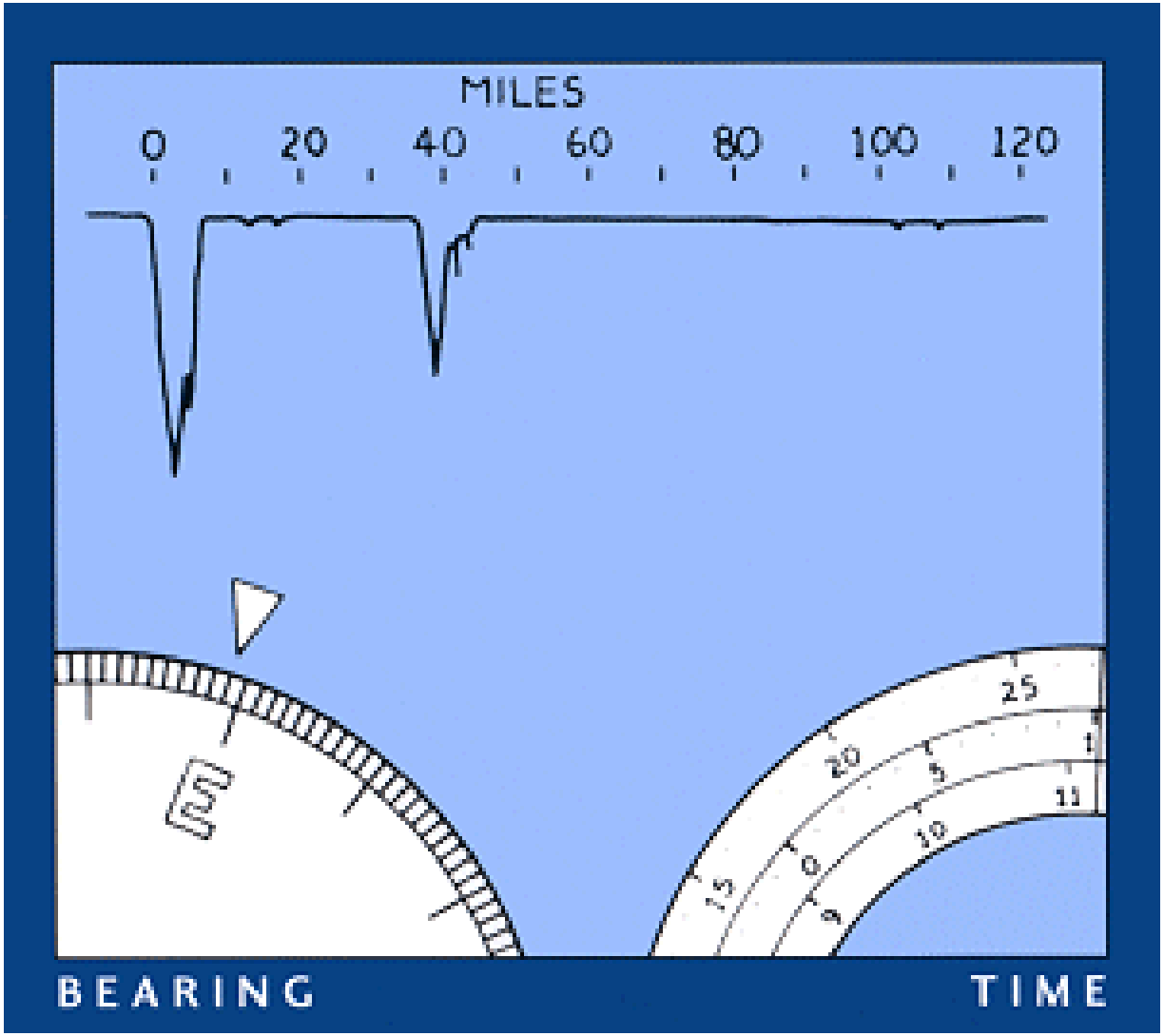

The Battle of Britain

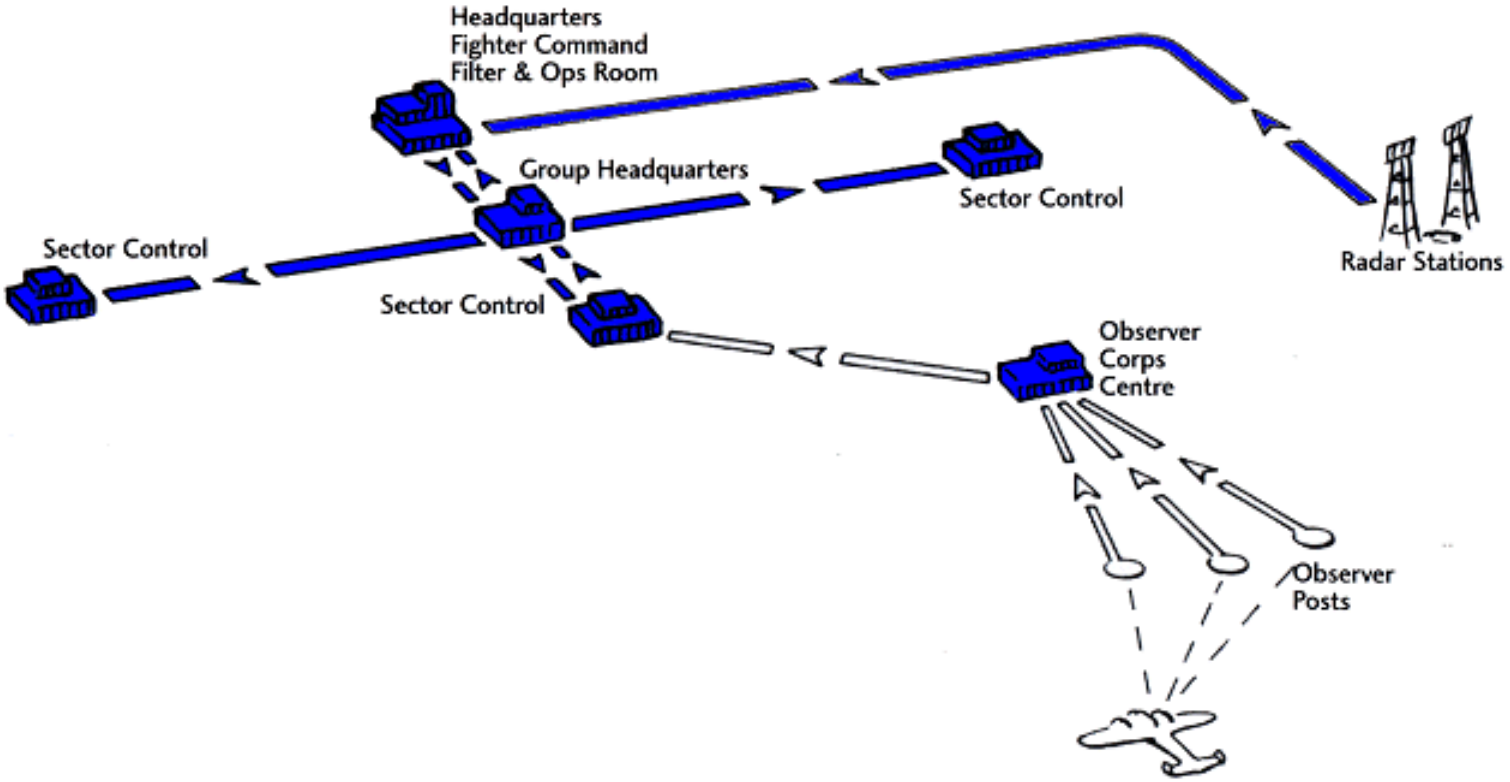
Fighter Command Organization


COLTISHALL
WITTERING
NORWICH
Stoke Holy Cross
Birmingham
COVENTRY
Dunwich
BURY ST. EDMUNDS
CAMBRIDGE
BEDFORD
DUXFORD
MARTLESHAM
Bawdsey
DEBDEN
COLCHESTER
Walton
GLOUCESTER
OXFORD
WATFORD
N. WEALD
Harwich
H.Q.F.C.
London
NORTHOLT
SOUTHEND
HORNCHURCH
COLERNE
GRAVESEND
EASTCHURCH
CROYDON
DETLING
MANSTON
KENLEY
BIGGIN HILL
MAIDSTONE
MIDDLE WALLOP
HORSHAM
HAWKINGE
LYMPNE
WINCHESTER
Southampton
TANGMERE
WARMWELL
Portsmouth
Ventnor
Beachy Head

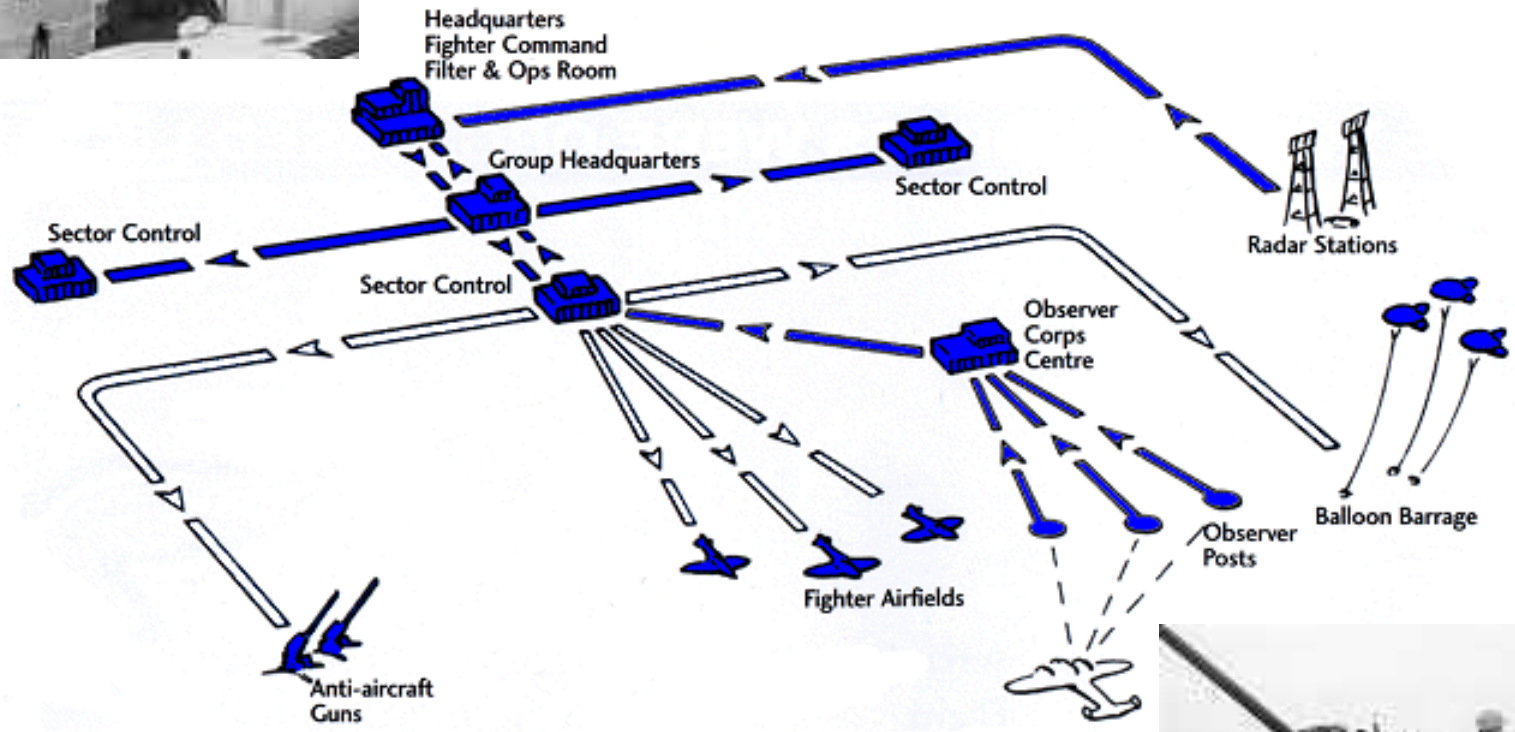

Headquarters
Fighter Command
Filter & Ops Room
Group Headquarters
Sector Control
Sector Control
Sector Control

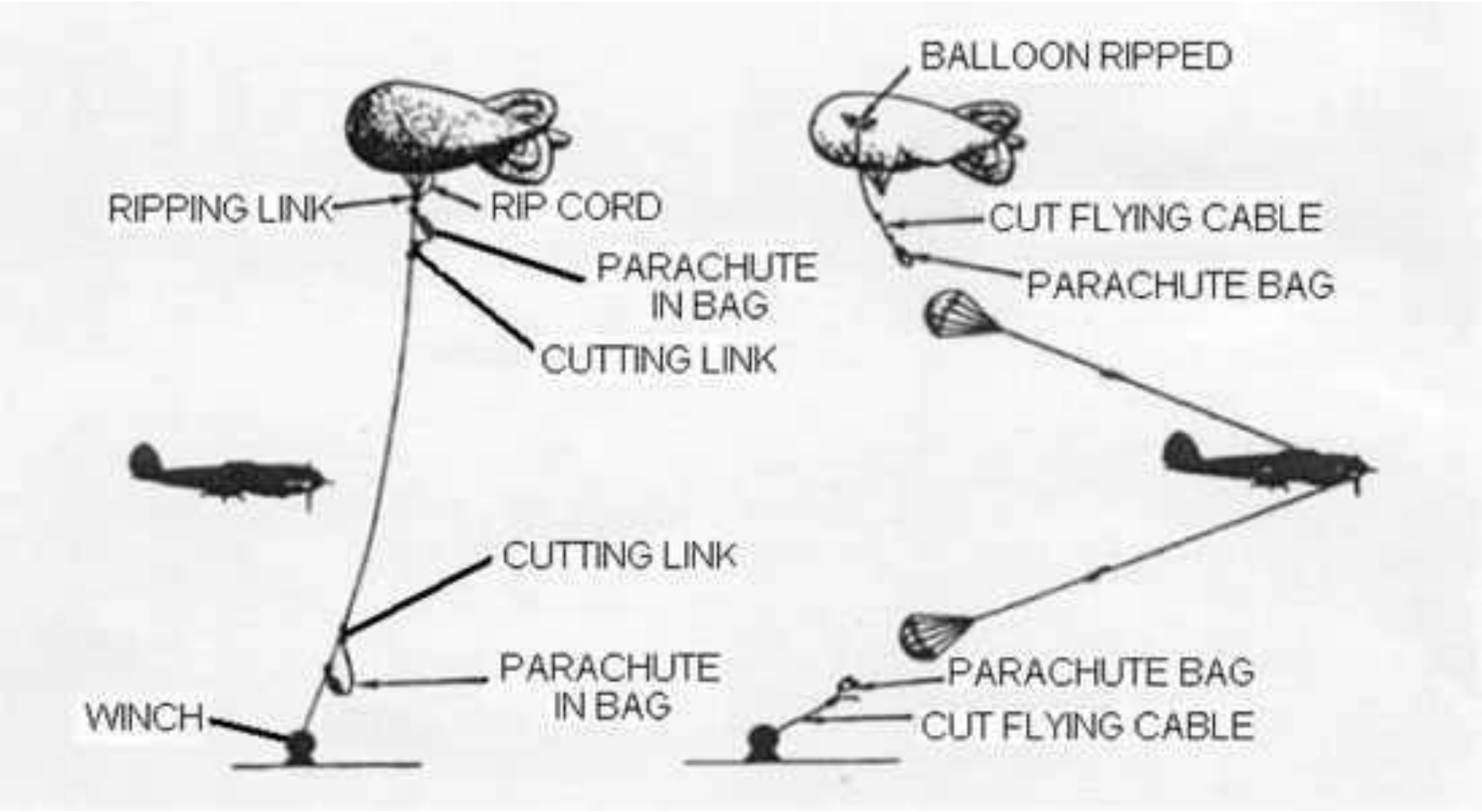

Headquarters
Fighter Command
Filter & Ops Room
Group Headquarters
Sector Control
Sector Control
Sector Control
Radar Stations

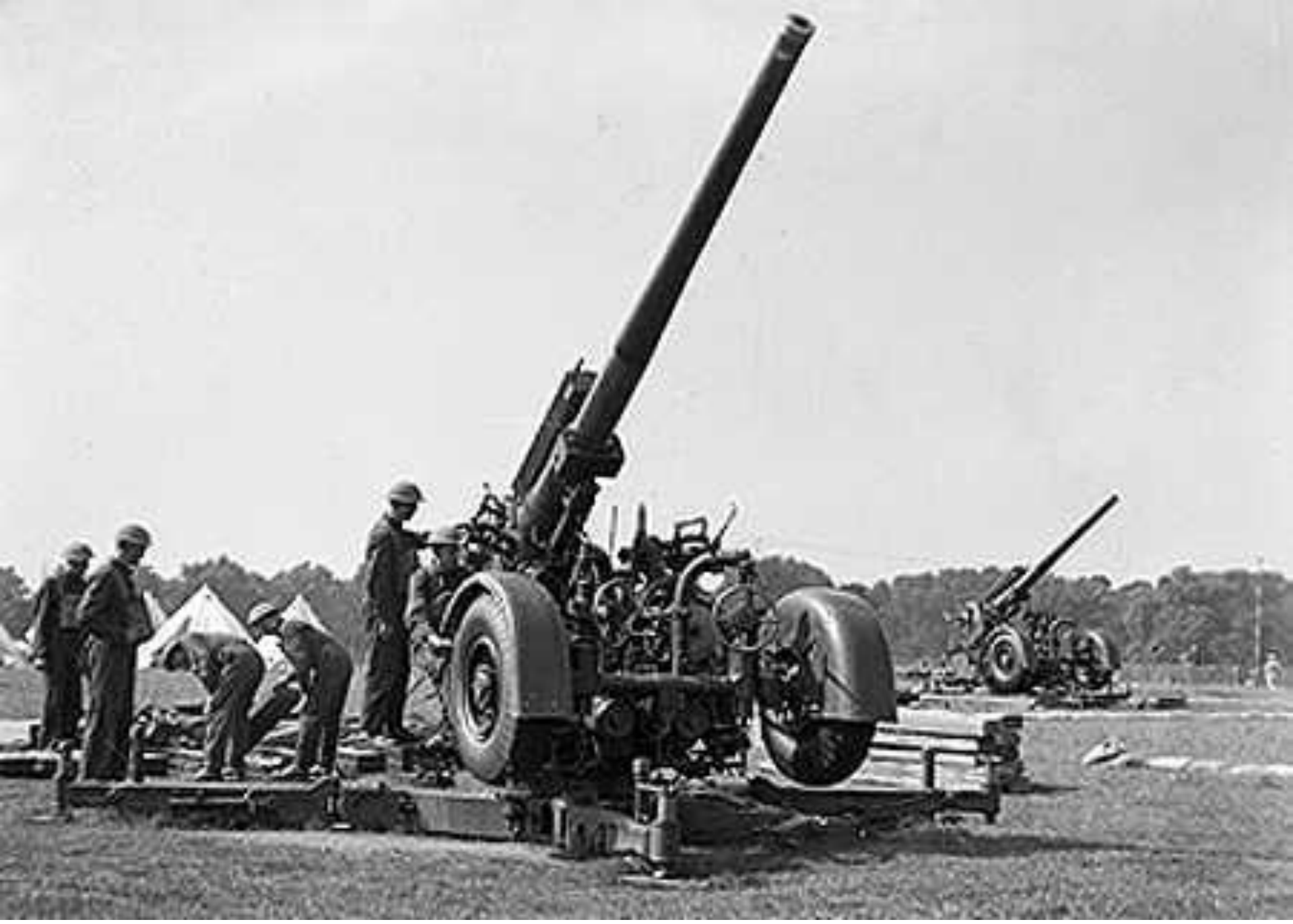

MILES
0
20
40
60
80
100
120
BEARING
TIME

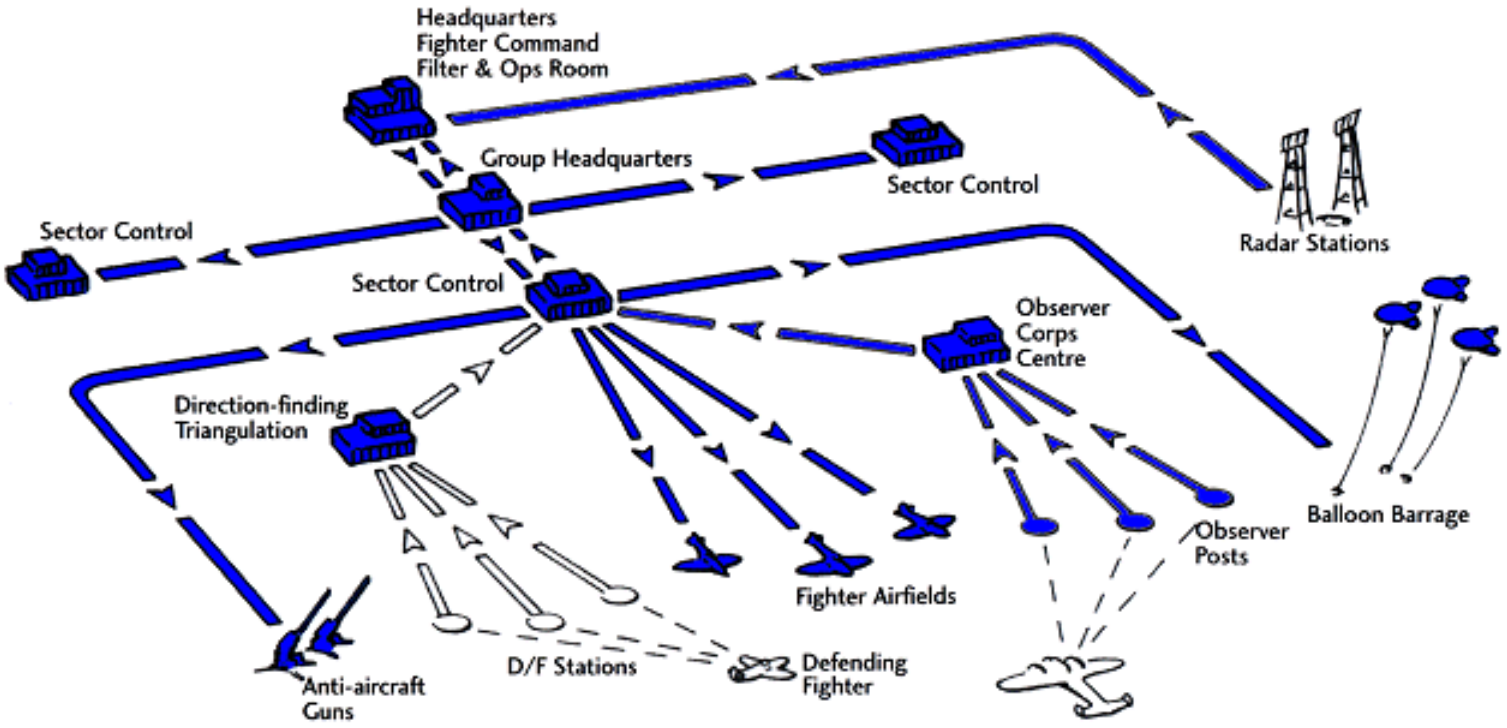

Headquarters
Fighter Command
Filter & Ops Room
Group Headquarters
Sector Control
Sector Control
Sector Control
Radar Stations
Observer
Corps
Centre
Observer
Posts


NORTH


Headquarters
Fighter Command
Filter & Ops Room
Group Headquarters
Sector Control
Sector Control
Sector Control
Radar Stations
Observer
Corps
Centre
Balloon Barrage
Observer
Posts
Fighter Airfields
Anti-aircraft
Guns

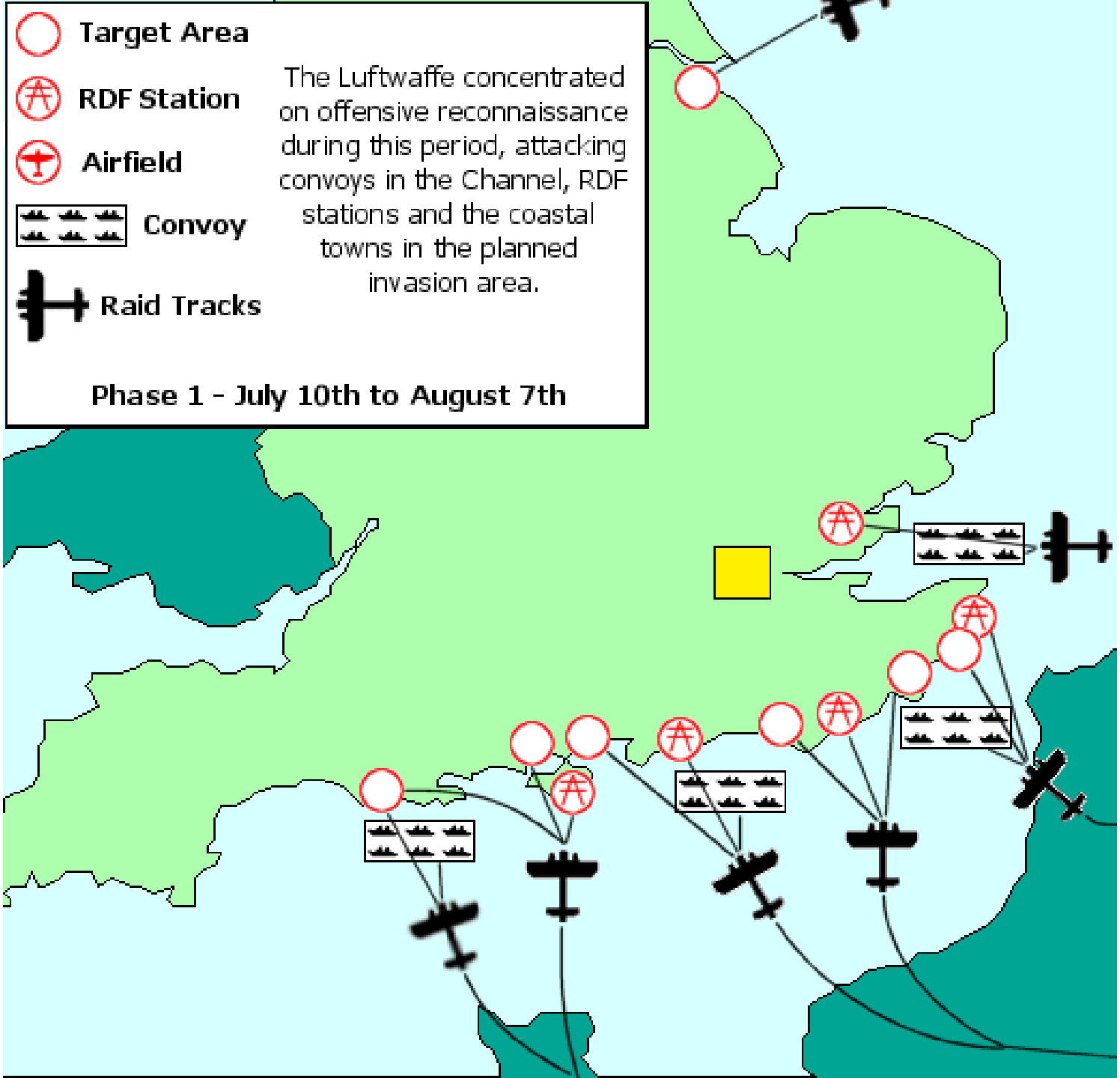

BALLOON RIPPED
RIPPING LINK
RIP CORD
CUT FLYING CABLE
PARACHUTE
IN BAG
PARACHUTE BAG
CUTTING LINK
CUTTING LINK
PARACHUTE
IN BAG
PARACHUTE BAG
WINCH
CUT FLYING CABLE

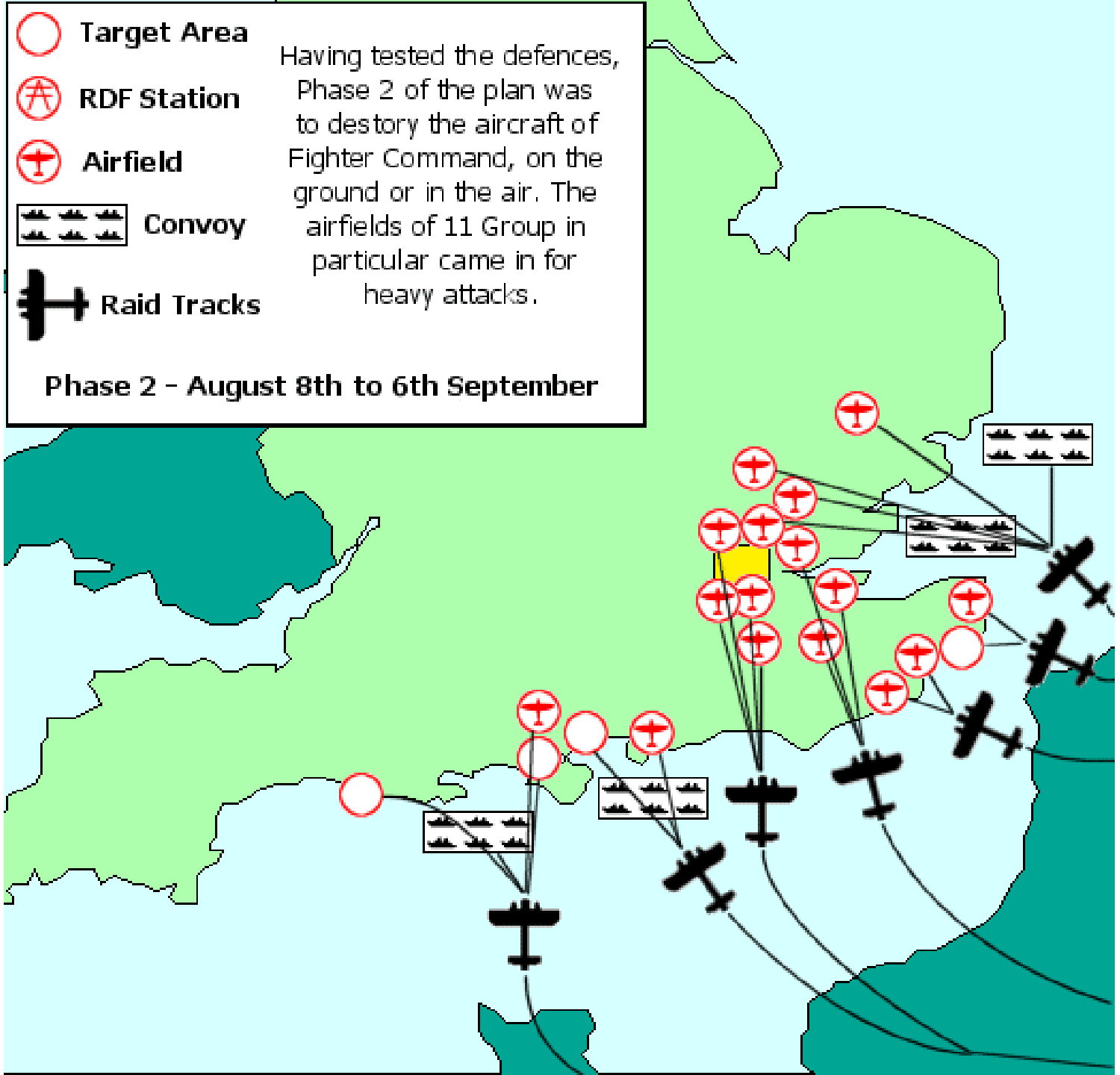


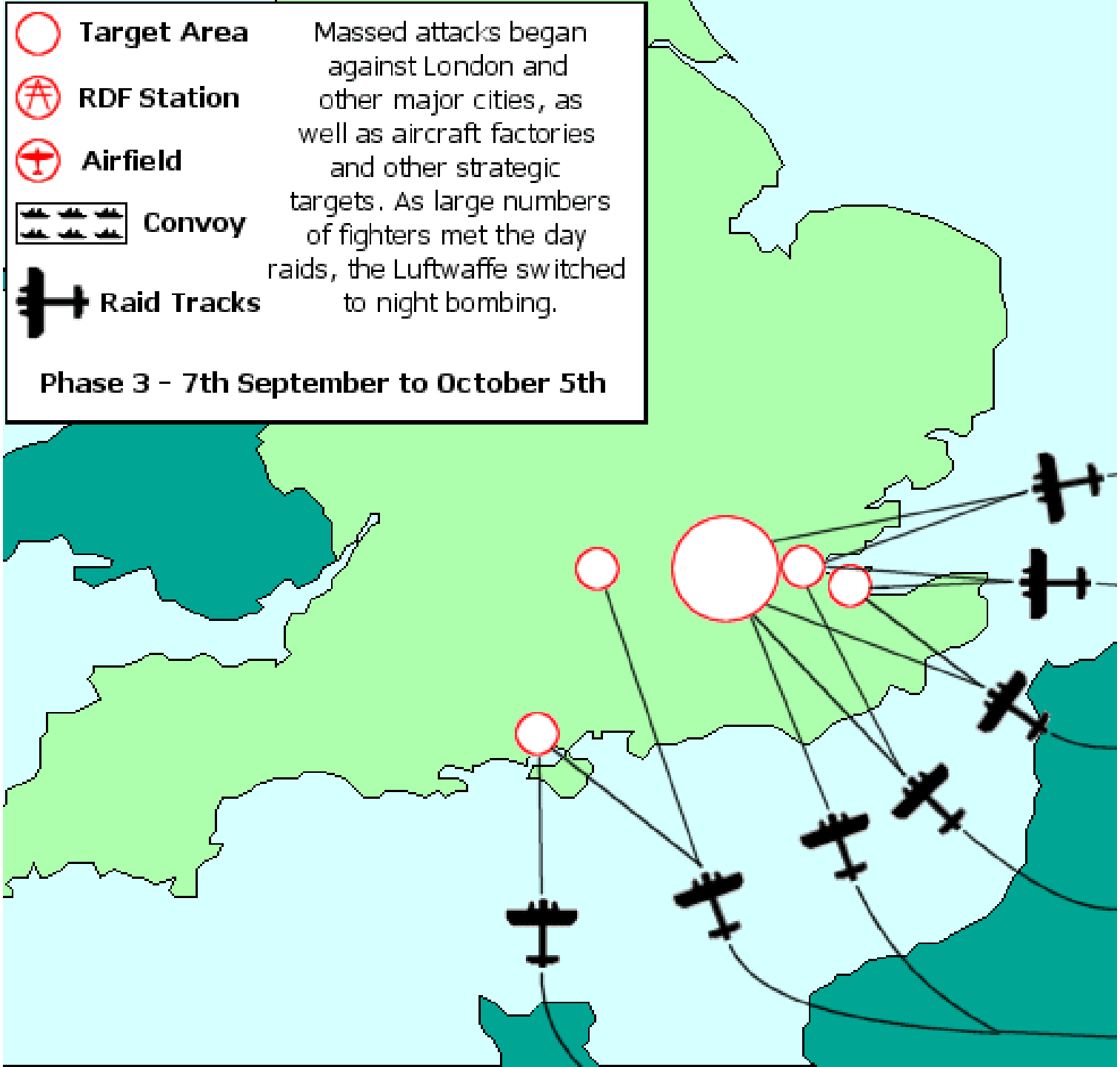

Headquarters
Fighter Command
Filter & Ops Room
Group Headquarters
Sector Control
Sector Control
Radar Stations
Sector Control
Observer
Corps
Centre
Direction-finding
Triangulation
Balloon Barrage
Observer
Posts
Fighter Airfields
Anti-aircraft
Guns
D/F Stations
Defending
Fighter

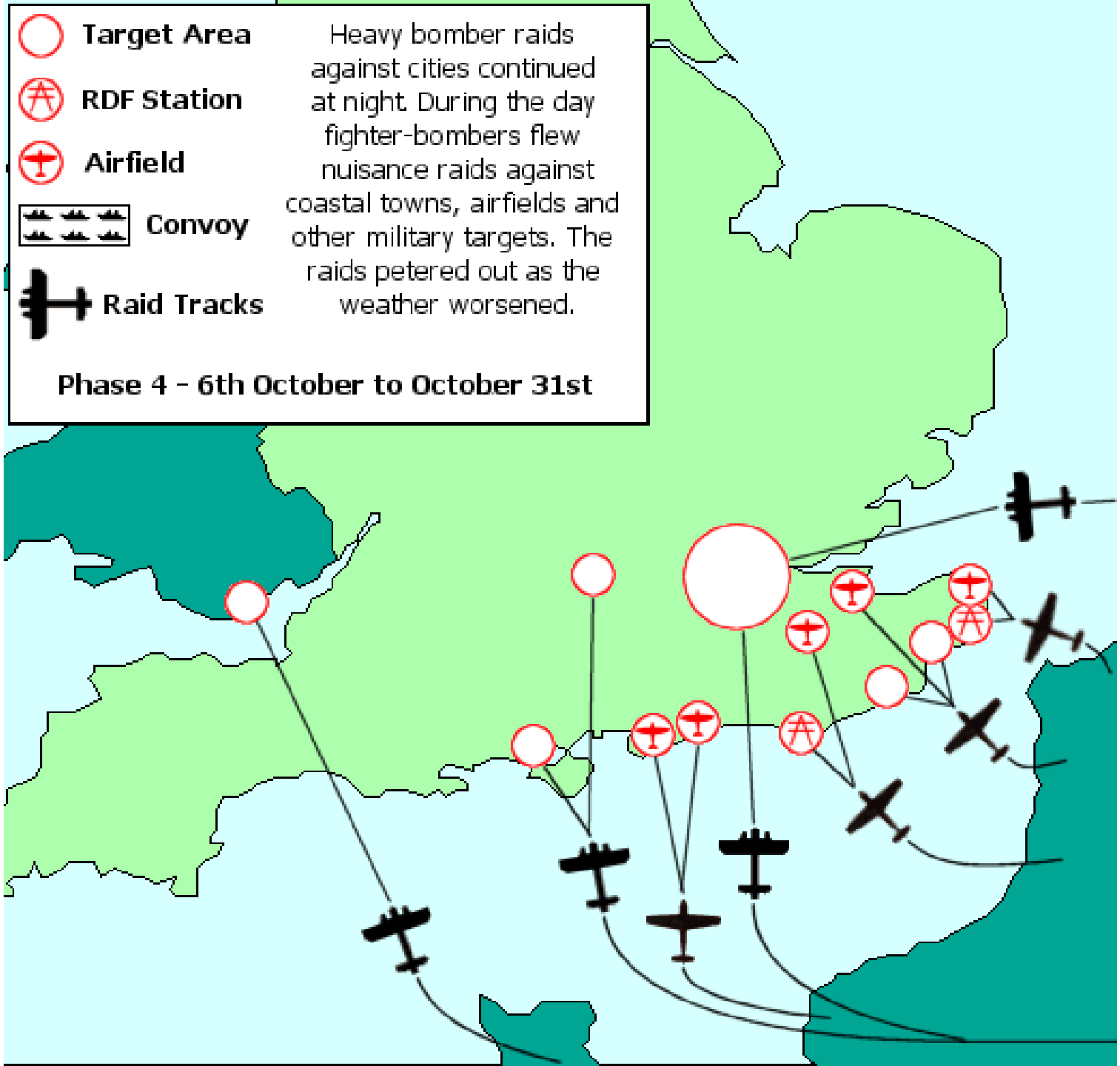
The Battle of Britain

- Phase 1 – 10 July to 7 August 1940
  - Attacks on Channel convoys and targets in the planned invasion area.
- Phase 2 – 8 August to 6 September 1940
  - Attacks on the fighters and airfields of Fighter Command.
- Phase 3 – 7 September to 5 October 1940
  - Attacks on London and the cities, gradual shift to nighttime bombing, the Blitz.
- Phase 4 – 6 October to 31 October 1940
  - Continuing attacks on the cities, but worsening weather.

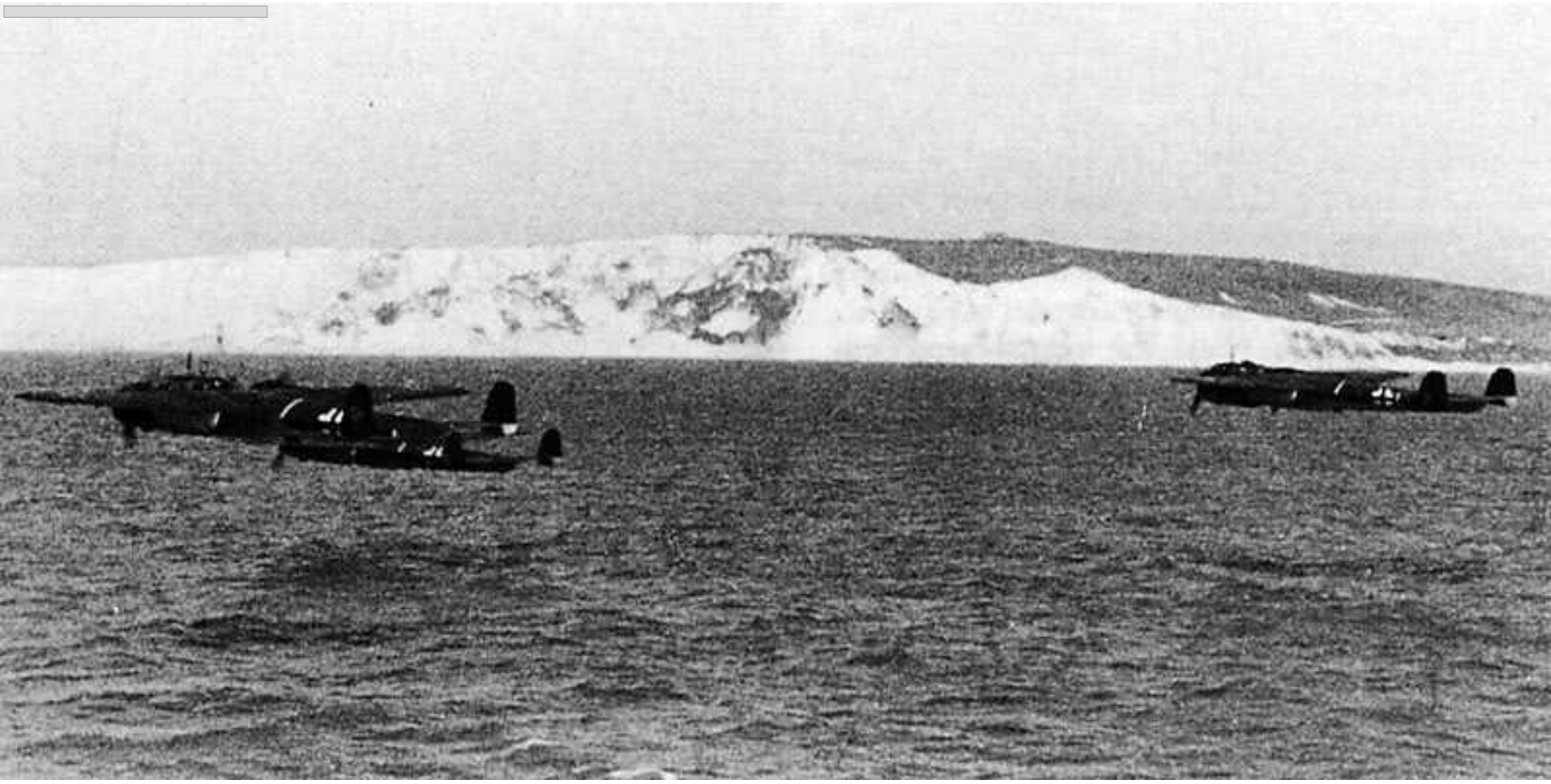

Target Area
RDF Station
Airfield
Convoy
Raid Tracks
The Luftwaffe concentrated on offensive reconnaissance during this period, attacking convoys in the Channel, RDF stations and the coastal towns in the planned invasion area.
Phase 1 - July 10th to August 7th


Target Area
RDF Station
Airfield
Convoy
Raid Tracks
Having tested the defences, Phase 2 of the plan was to destory the aircraft of Fighter Command, on the ground or in the air. The airfields of 11 Group in particular came in for heavy attacks.
Phase 2 - August 8th to 6th September


Target Area
RDF Station
Airfield
Convoy
Raid Tracks
Massed attacks began against London and other major cities, as well as aircraft factories and other strategic targets. As large numbers of fighters met the day raids, the Luftwaffe switched to night bombing.
Phase 3 - 7th September to October 5th

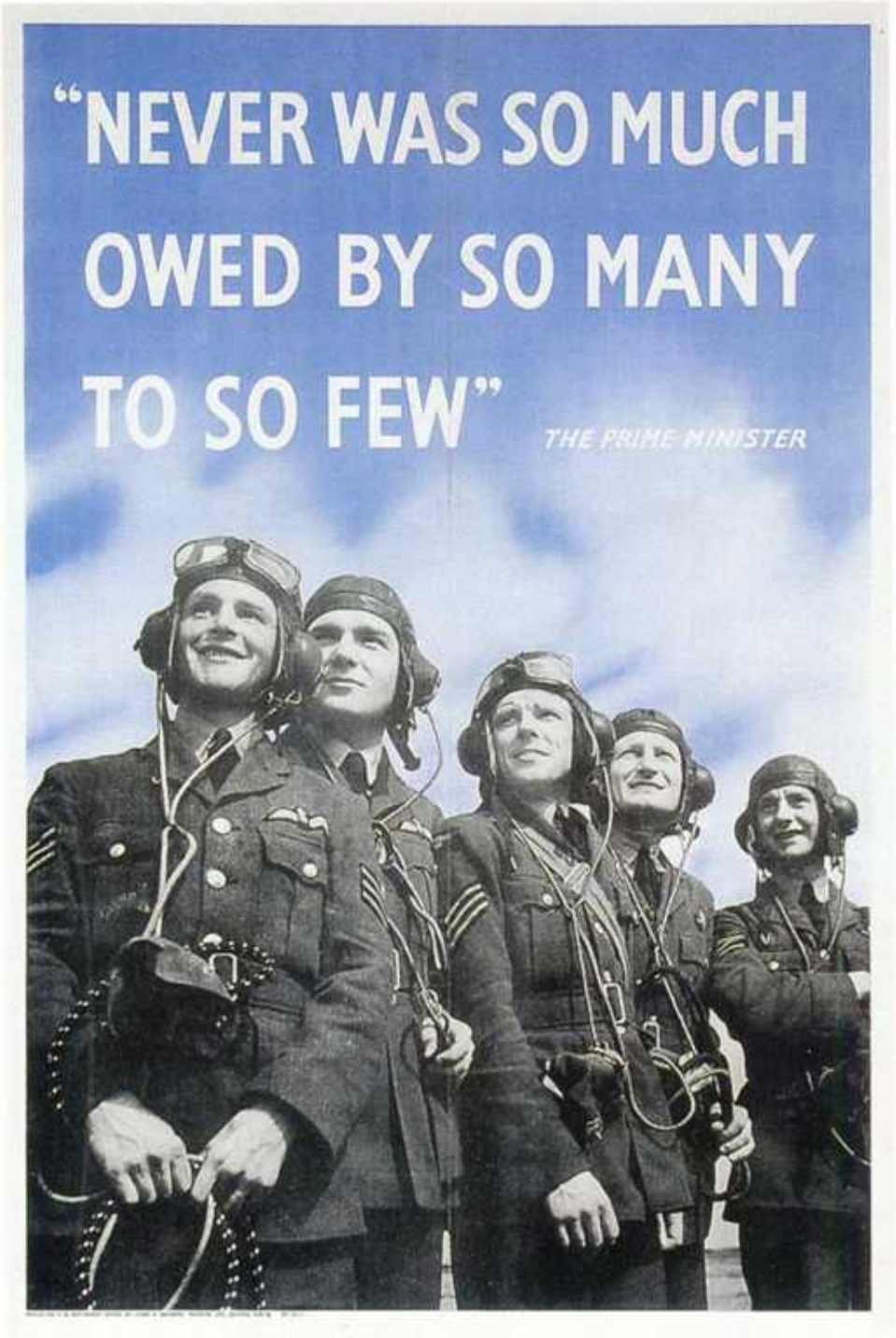

Target Area
RDF Station
Airfield
Convoy
Raid Tracks
Heavy bomber raids against cities continued at night. During the day fighter-bombers flew nuisance raids against coastal towns, airfields and other military targets. The raids petered out as the weather worsened.
Phase 4 - 6th October to October 31st


R OFY
F OFY



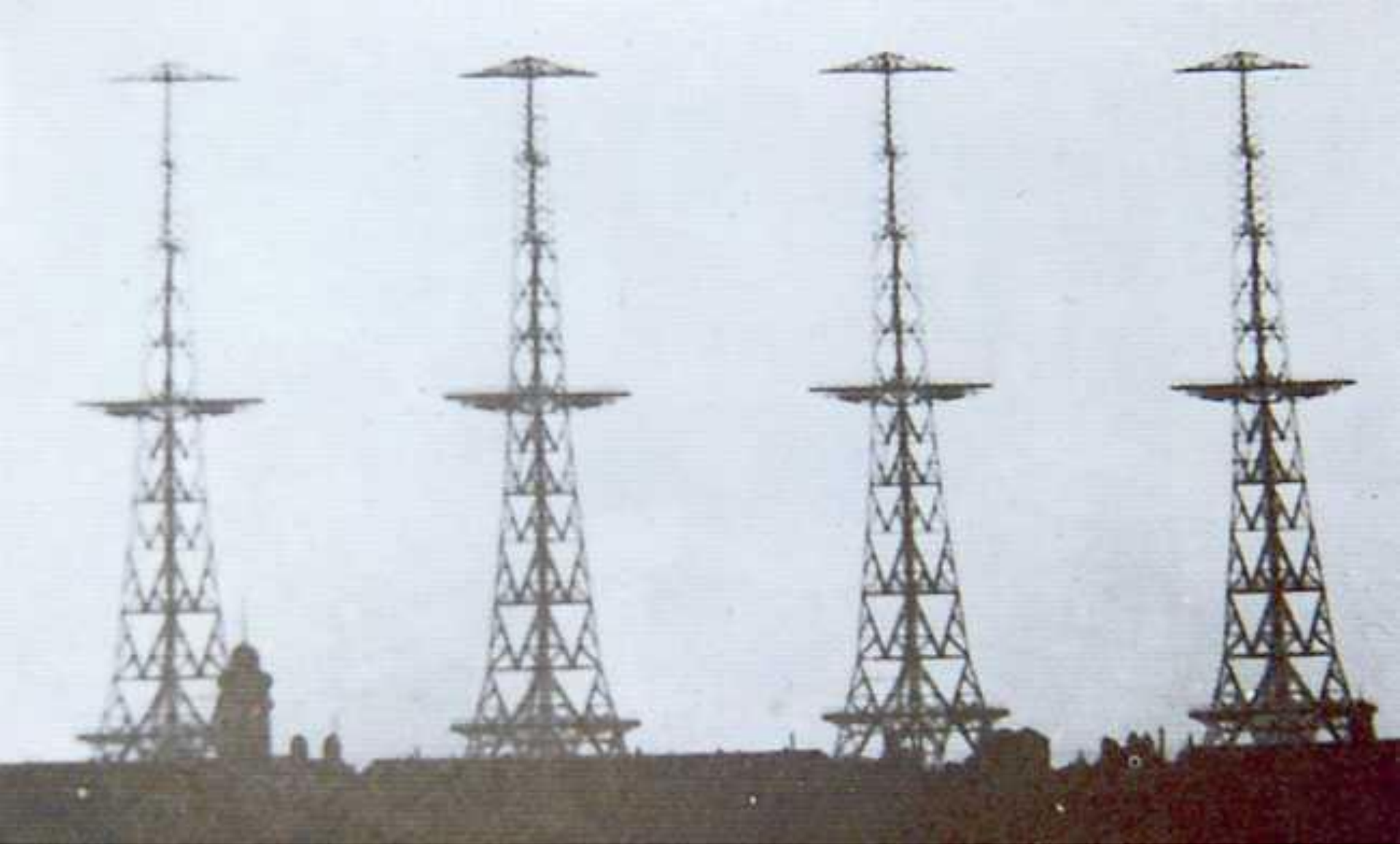

AF
A

The Few

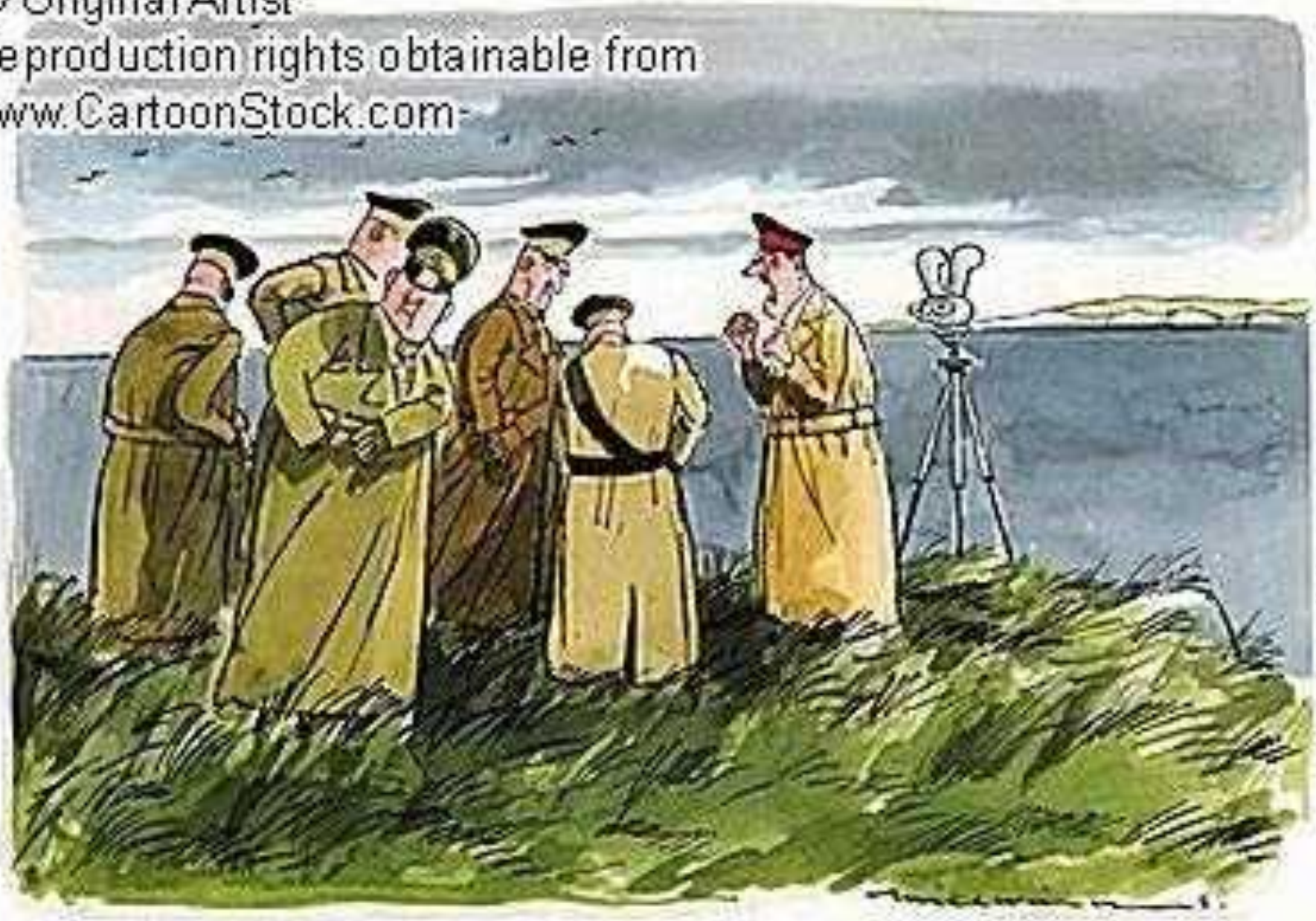

"NEVER WAS SO MUCH
OWED BY SO MANY
TO SO FEW"
THE PRIME MINISTER

Conclusion

- Primitive, slow, poor low-level coverage, etc. - Chain Home Radar had a lot of faults.
- BUT, it was the right system, ready just in the nick of time!
- The tactical advantages provided not just by CH Radar, but by the entire Command and Control system as a whole, proved decisive in the Battle of Britain.



Questions?



"Gott in Himmel! Somebody must have a franc!!!"


EB H
EB D
EB B