"The Right Tunes? Wavemeters for British Army and Air Force uses in World War One time"

Anthony C Davies

KINGSTON UNIVERSITY

"The Right Tunes? Wavemeters for British Army and Air Force uses in World War One time"

Anthony C Davies

Emeritus Professor, King's College London

and

Visiting Professor, Kingston University, Surrey

My Credentials?

Once an electronics engineer, NEVER a historian -

but

in Signals Section of school cadet force

and then

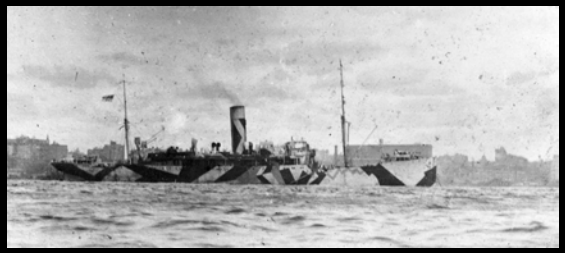
in British Army (*REME*), trained in Maintenance and Repair of transmitters and receivers.

My Credentials?

Souvenir from W.O. and Sergeants' Mess, REME, Arborfield,

My Ancestry

My father served at sea throughout both World Wars



Included service under Capt. Howard J.L.W.K. Willcox on HMS Changuinola, Convoy Duty North Atlantic, 1918-1919

I think that Willcox was Navigating Officer under Jellicoe at Battle of Jutland

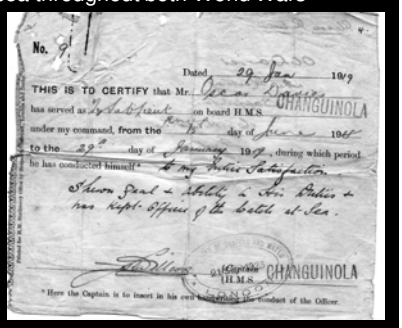
Photo: The National Archives, Kew

My Ancestry

My father served at sea throughout both World Wars

On HMS Changuinola, North Atlantic, WW1

Photo: O.C. Davies



1919: Discharge Certificate signed by Capt. Howard Willcox R.N.

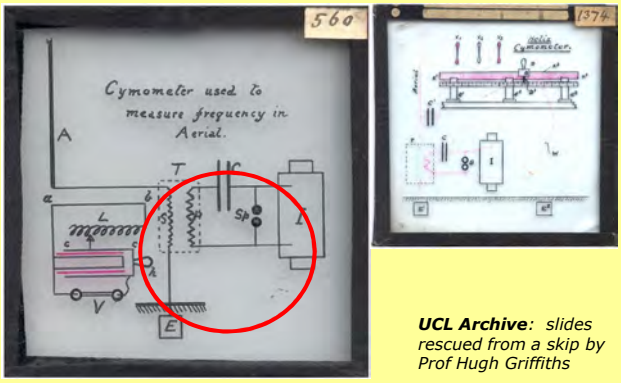
My Ancestry

My father was Torpedoed at least once in WW1

My Ancestry

Music composed by a distant relative of mine

Prof J.A. Fleming (University College London) claimed invention of the wavemeter (he called it a Cymometer) in October 1904



***UCL Archive**: slides rescued from a skip by Prof Hugh Griffiths*

Prof Fleming (University College London) wavemeter invention (Cymometer – not a Cynometer!).

Claimed Quotation of Prof. J.A. Fleming:

"…… The wavelength of the electric waves sent out from Poldhu Marconi station in 1901 was not measured because I did not invent my cymometer or wavemeter until October 1904 ….."

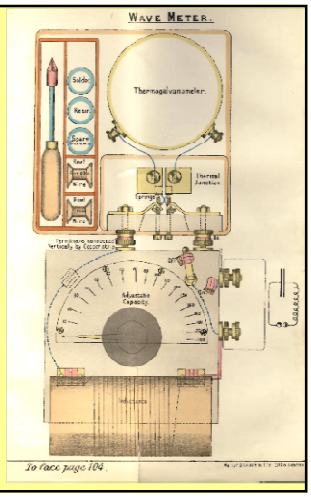
Wavelength actually used is variously reported to have been ~ 3000 feet or ~1200 feet

Wavemeters had been invented and described in Germany before that, and it seems that there might have been wavemeters commercially available there by 1904 and more soon after (at least from Siemens & Halske)

Admiralty Draughtsmen's excellent work!

Drawing of 1906 Marconi Absorption Wavemeter

From Admiralty document, in collection of HMS Collingwood Museum



Admiralty

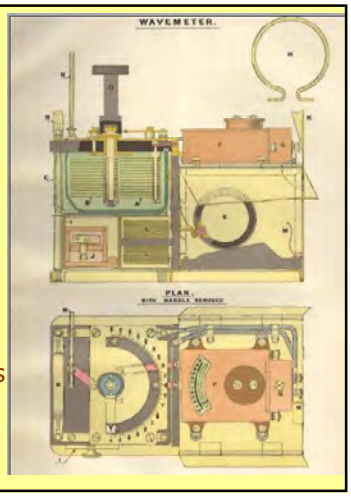
Absorption Wavemeter

Pattern Number 1492

1913 design used for many years (1917 drawing)

300m -4000m

used in HMS Hood: a 1913 Navy Report says *"in 26 ships at sea"*



Drawing in collection of HMS Collingwood Museum

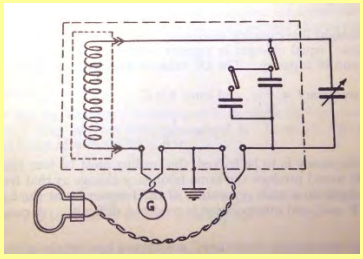
Admiralty

Absorption Wavemeter

Pattern Number 1492

(1917)

300m -4000m



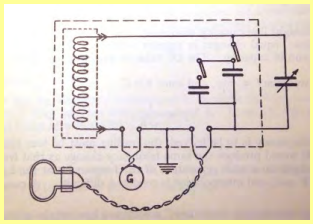
Wavemeter in collection of HMS Collingwood Museum

Admiralty

Absorption Wavemeter

Pattern Number 1492

300m - 4000m



Despite the development of many more advanced wavemeters, variants of the simple but reliable Pattern 1492 stayed in use for many years.

*An Admiralty book of orders (**A.F.Os. 5358 -5488/42**) dated 5th November 1942 details the process to dispose of these and other obsolete wavemeters.*

AFO = Admiralty Fleet Orders

Remember:

*Early Transmissions were **Morse Code**, and used spark transmitters, there was no speech communication.*

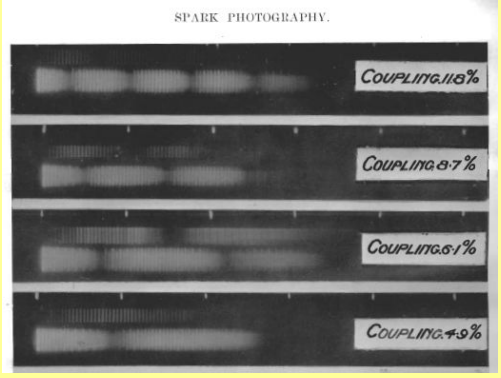
Spark transmitters created a periodically-repeated damped oscillation, interrupting the transmission frequency at an audible rate.

The Navy also used the Poulsen Arc, creating a somewhat purer tone.

High frequency alternators were also used, which produced a continuous wave.

Modern CW and MCW Morse transmissions were developed later, and still in regular use in World War Two. World War One receivers had no BFO, so generally could not receive pure CW

The Admiralty sent wavemeters to NPL for calibration: this was done by high-speed photography of the spark-train, and the appearance enabled them to decide the L and C calibration,



Wavemeter

Absorption or Heterodyne

Cymometer

Syntoniser

Wellenmesser

Ondemètres

Decremeter

- used to measure damping of the spark-train,

- which controlled the bandwidth

Initially believed *only one high power spark transmitter could operate in one area at a time, because a receiver would respond to all.*

Marconi then demonstrated 'tuning' such that two could be operated simultaneously by using very different wavelengths:

Navy had a practice of setting aside time for adjusting receivers, by having the transmitter send slow Morse Code "VVV" for two minutes, during which times no communications could take place.

Quite early on, Navy started using Arc and Alternator in place of Spark: The Army and Flying Corps/RAF persisted with Spark transmissions until using some valve sets later for CW transmissions.

Admiralty *used 'A' (400ft = 2.5MHz) and 'B' (1025feet=950kHz) tunes from 1906*

Wanted to use a complete set of different tunes and to keep the wavelengths secret from potential enemies!

Frequency separations based on an objective of no mutual interference at receivers if using maximum power at 2-miles separation

Speech and music transmissions considered frivolous with no commercial or other value: but later, RAF were beginning to use speech because of the difficulties of keying Morse while flying in a small fighter plane.

British Army

WW 1

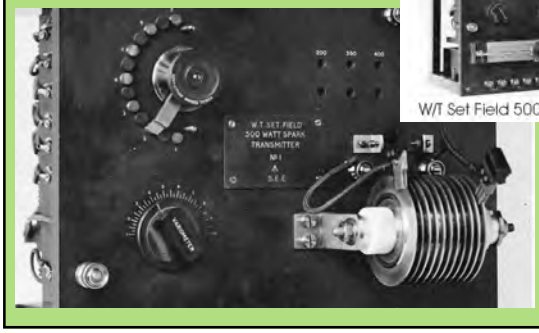
Muelstee describes † nearly 20 different spark transmitter sets used over 1914 to1918, with ranges from 5 miles to 500 miles!

The Marconi Wagon Set (1914) weighed 3 tons, and generated 1.5 kW at the spark.

Wavemeters included: Station Tester Mk.I and II (1915), Forward Sets B wavemeter (1917), Forward Sets B Wavelength Standard No.1, and, from1918, several Townsend Wavemeters (same design, different frequency ranges)

† *Compendium No 1*

Example spark set (from Muelstee)

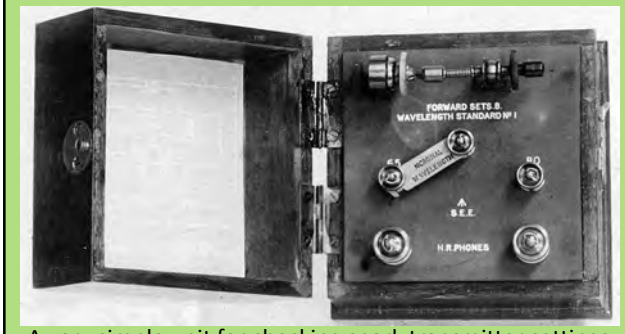


W/T Set Field 500 watt Spark

British Army

WW 1

Forward Sets B Wavelength Standard (from Muelstee)



A very simple unit for checking spark transmitter settings

British Army

WW 1

Station Tester Mk II

From Royal Signals Museum, Blandford Forum. Photo: © K.Thrower

British Army

WW 1 (1917)

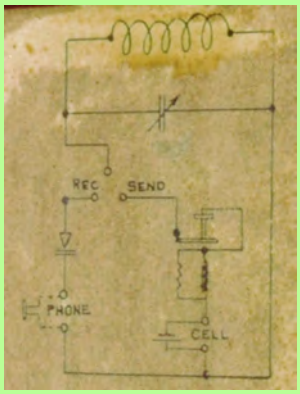
"Forward Sets B" Wavemeter

65m** and **80m

RAF Henlow Museum Collection

British Army *WW 1 (1917):*

"Forward Sets B" Wavemeter



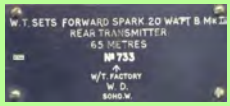
65m** and **80m

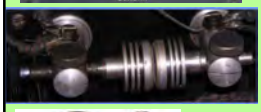
Circuit extracted from Keith Thrower photo

British Army

WW 1

Spark Transmitter ("Loop Set")

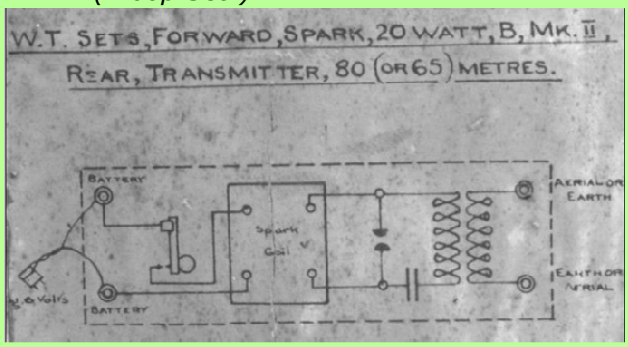




Kurrajong Radio Museum Collection, used with permission

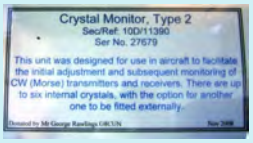
British Army

WW 1 ("Loop Set")



Kurrajong Radio Museum Collection, used with permission

Air Force



RAF Henlow Museum Collection

Royal Air Force

Initially:

***Royal Naval Air Squadron** under Navy control*

***Royal Flying Corps** under Army control*

These were independent, with effectively no cooperation

*Against some opposition, in April 1918, the two were combined to form the **Royal Air Force**, under the independent Air Ministry*

Royal Flying Corps

They used
Townsend Wavemeters

designated
Nos. 1, 2, 3.

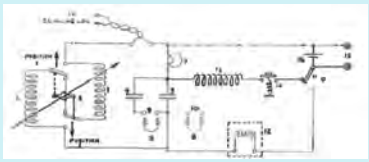
1000m to
4000m

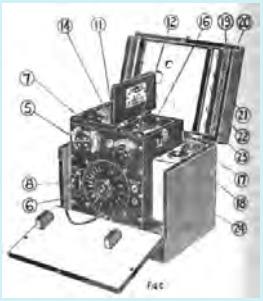
Photo source unknown

Royal Air Force

Wavemeter W3, ~ 1918
design
75 – 1000 kHz in four ranges

For use in aircraft
with sets T21C and T22





From HMS Collingwood Museum document

Air Force

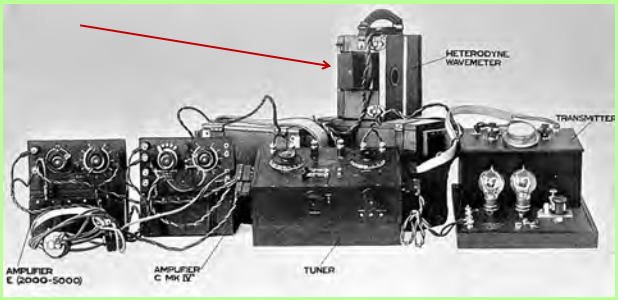
By 1917, a Heterodyne Wavemeter was introduced for use with CW transmissions: *"as easy as working with the ordinary wavemeter .. in which a buzzer is used."* .

Air Force

Heterodyne Wavemeter:
The single valve used, and one of the plug-in inductors.

Air Force ⟶ British Army

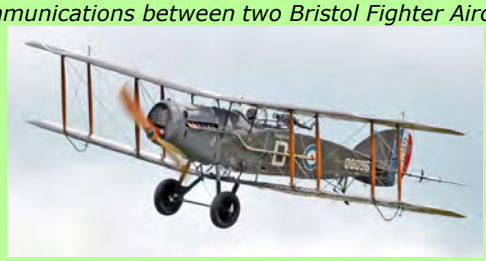
The same Heterodyne Wavemeter:
…. in use with **Army** CW W/T Field 60W set.



(from Muelstee)

Air Force

Aircraft were used with radios to report to ground troops, directing artillery fire – then ……..
By 1917, Aircraft R/T was beginning: for communications between two Bristol Fighter Aircraft



Clearly very difficult for the pilot to fly the plane AND operate a Morse Key! So speech communications was an obvious need.

Wavemeter Types relevant to WW1

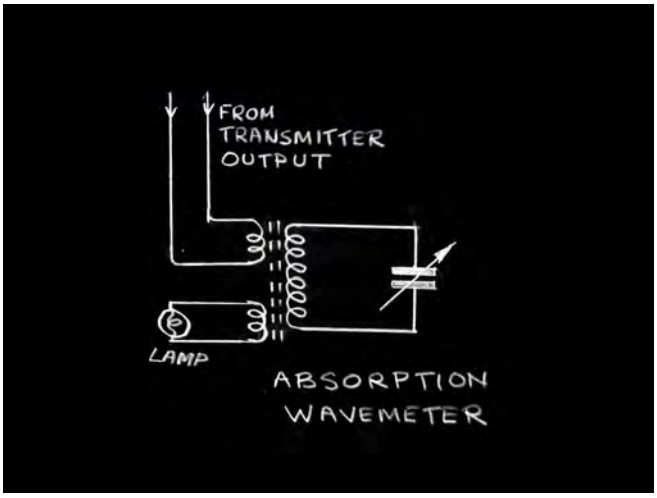
Absorption wavemeter

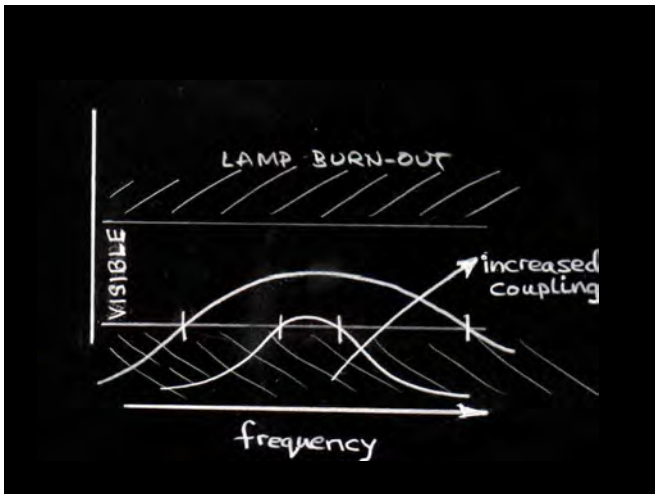
Simple, easy to use correctly, imprecise

Heterodyne wavemeter

Skill required to use correctly, can be very accurate

Counter-based frequency-meters came MUCH later (after WW2)





Military Requirements:

Setting Transmitter Frequencies

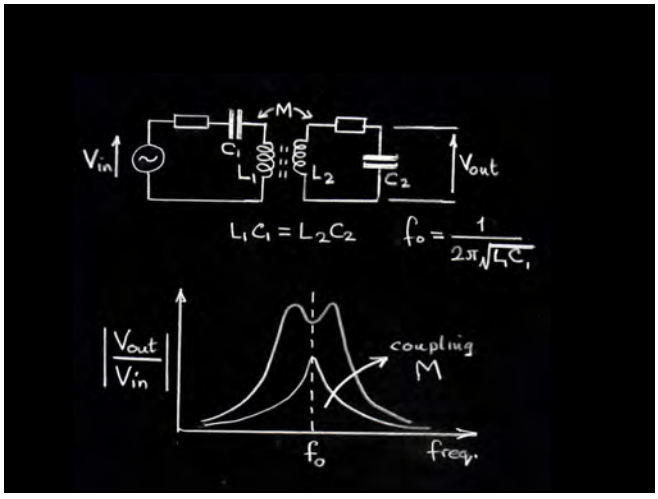
Adjusting Receivers to tune to the correct Transmission.

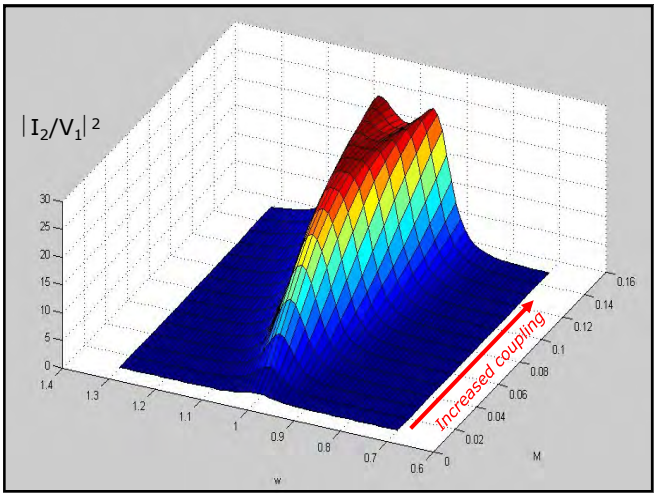
More recent needs:

1. *Maintaining frequencies of communications networks, ensuring that receivers and transmitters are tuned to the correct frequencies*

2. *Special military needs such as discovery of enemy location, strategies by interception and direction finding of enemy transmissions, misleading enemy by false signals, cyber attacks on enemy assets.*

(part of what we now call '*electronic warfare*')





Admiralty:

Wavemeter No1,

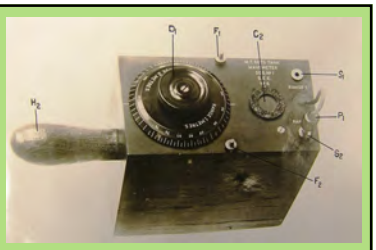
made in Signal School

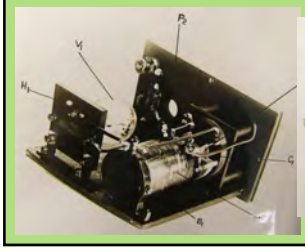
Now at HMS Collingwood

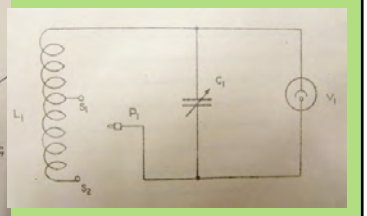
British Army

Example:

Absorption wavemeter for Tank use.
Note wooden handle and circuit simplicity







Royal Air Force

Townsend Wavemeter Example

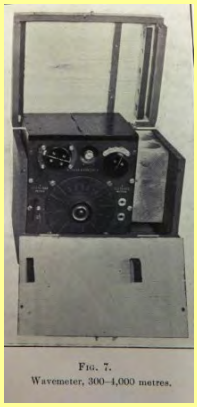
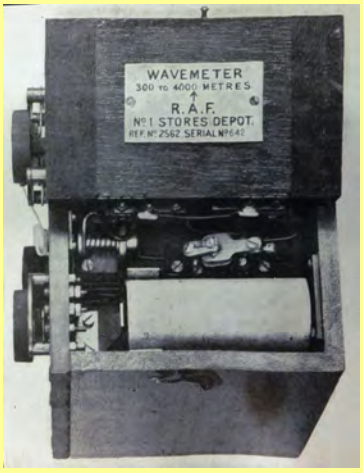


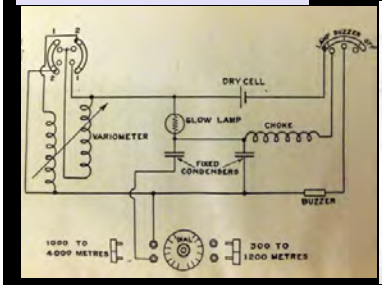
Fig. 7.
Wavemeter, 300–4,000 metres.

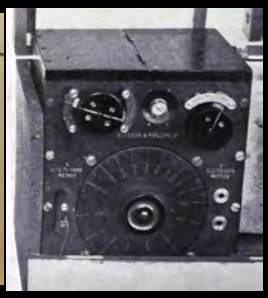


Royal Air Force

Townsend Wavemeter

What is inside:





Royal Air Force

Continuous wave Syntoniser:

One oscillating Valve which can generate any frequency in the range.

Uses only a single 6 volt battery.

Fig. 1.
Syntoniser, 300–2,500 metres.

Royal Air Force

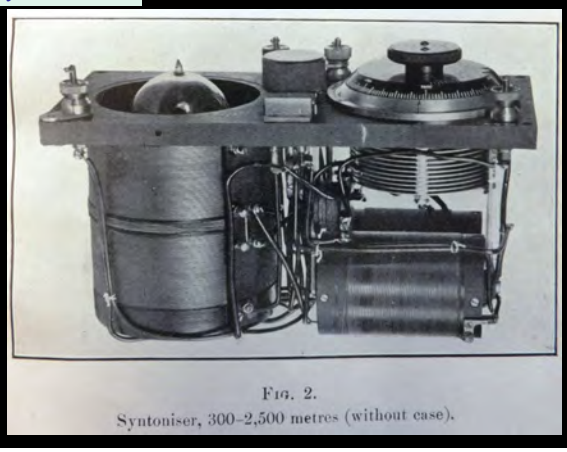


Fig. 2.
Syntoniser, 300–2,500 metres (without case).

Royal Air Force

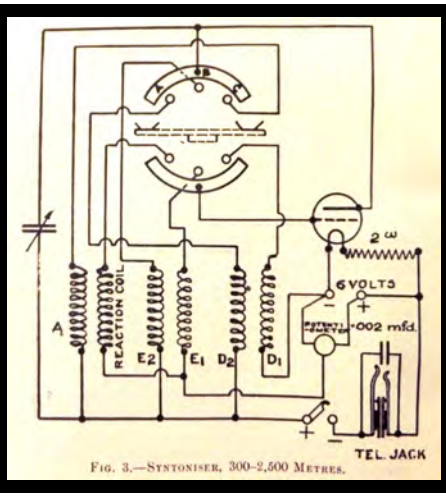


FIG. 3.—SYNTONISER, 300–2,500 METRES.

Royal Air Force

Their WW1 wavemeters formed the foundation for a large variety of novel and innovative wavemeters for RAF radio and, later, for radar, in the interwar years and throughout and after WW2

Tentative List of all RAF wavemeters: some may not have existed, some may be missing from list !

…. . . W3, W36A, W37, W39, W42, W63, W66, W67, W69, W75, W76, W1081, W1089,
W1095, W1117, W1158, W1191, W1160, W1160A, W1185, W1193, W1238, W1239,
W1242, W1243, W1310, W1409, W1411, W1432, W1433, W1479, W1605,W1615, W1616, W1617, W1631, 1635, W1643, W1646, W1649, W1650, W1651, W1652, W1653
,W1655 ?,W1664, W1665, W1691, W1910 …

Royal Air Force

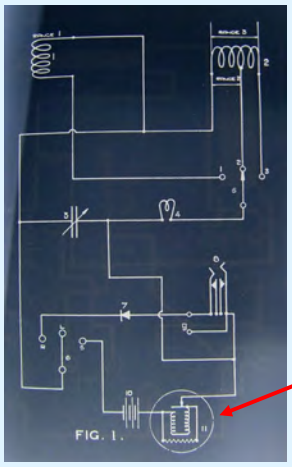
W37 wavemeter

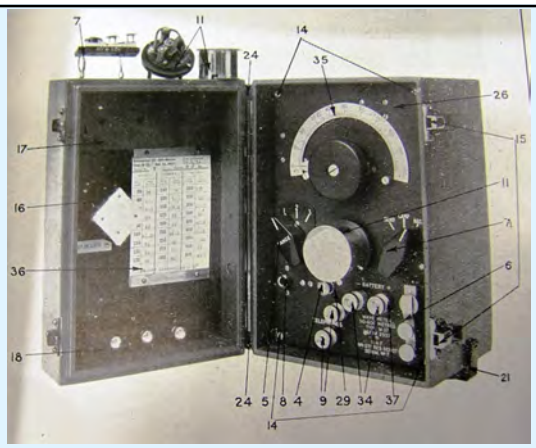
1925

500kHz-6MHz

Royal Air Force

W37 wavemeter

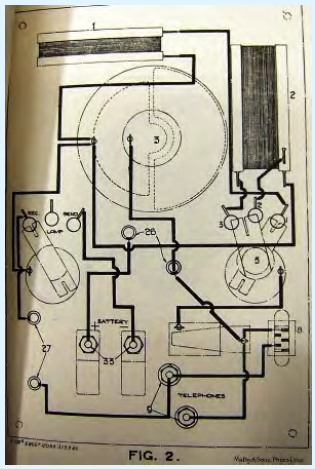




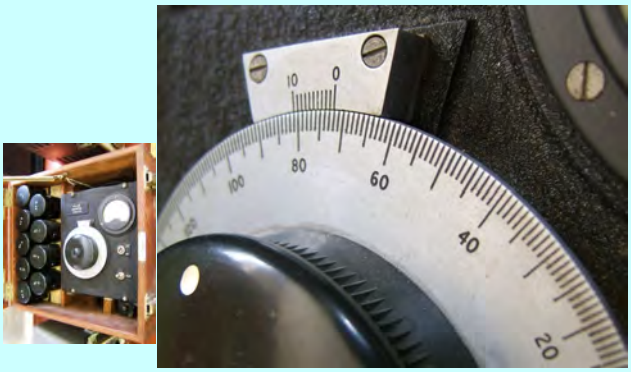
W37 wavemeter

Royal Air Force

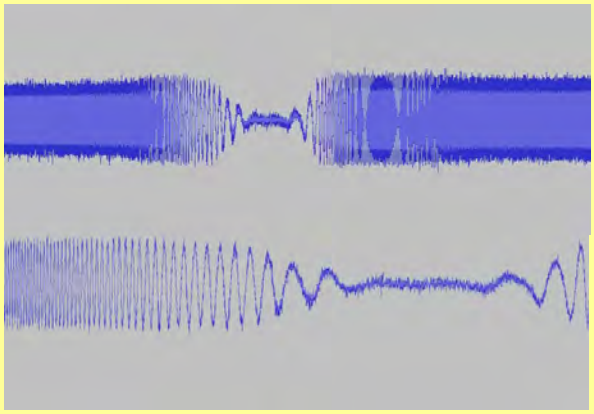
W37 wavemeter



Precision vernier to adjust capacitance and read the scale, *R502 wavemeter ≡ Admiralty G92 wavemeter*



Tuning for Zero Beat



BC-221: danger of tuning to wrong harmonics
- can result in huge errors

c. Measurement of Local Transmitter, Approximate Frequency Unknown. To measure accurately the emitted frequency of an adjacent transmitter or oscillator, the frequency of which is unknown, determine first the approximate frequency with the aid of an absorption type wavemeter or a radio receiver; then determine actual frequency, b above. *If the receiver is being used for the above measurement, make sure that it is not tuned to a harmonic of the transmitter under measurement.*

Much later RAF wavemeter progress: W1191

Duxford Radio Society collection

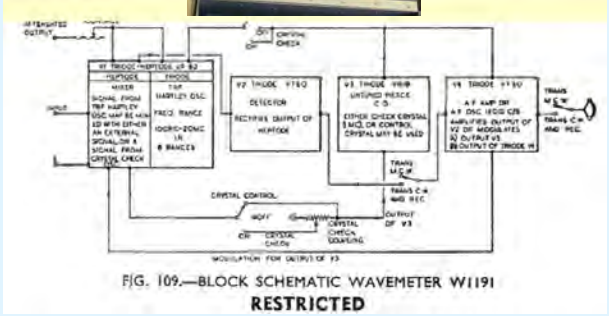


FIG. 109.—BLOCK SCHEMATIC WAVEMETER W1191
RESTRICTED

RAF wavemeter: W1646 (for Radar)
– with **Magic Eye indicator**

RAF Henlow collection

Time indicator on Greenwich Hill

We have come a long way since then . . . .

Photo Acknowledgements

REME Museum of Technology, Arborfield.

Duxford Radio Society, Imperial War Museum.

HMS Collingwood Museum.

RAF Henlow, RAF Neatishead and RAF Hendon.

Royal Signals Museum, Blandford Forum.

Kurrajong Radio Museum.

…. and many people to thank for information or photos or permissions to use photos.

For more information:

A.C.Davies, "Wavemeters: how frequency was measured in World War 2 time", Digest of HISTEST 2011, Bournemouth, England, 17-18 Sept 2011, p35-46.
A.C.Davies, "Wavemeters for Frequency Measurement by the British Army in World War Two" AWA (Antique Wireless Association) Review 2012, Vol 25, pp79-101.
A.C.Davies, "The Rise and Fall of the Military Wavemeter: British Military Wavemeters of the 20th Century", presented at HISTELCON 2012, Pavia, Italy, 5-7 September 2012.