Tricks of the Trade: Aspidistra and OSE5

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This is a story of two separate transmitter sites, both hurriedly engineered in the Second World War, both having similar output powers of 600 kW, both on the eastern side of the UK, and both intended for broadcasting to the Occupied and Axis countries. Much has been written since about programming and politick at Aspidistra, but the authors would guess that very few know anything at all about Over Seas Extension 5, OSE5. Moreover there is a dearth of material about engineering at both sites, and this article not only examines the general transmitter engineering, but also principally discusses the combining systems for high power transmitters. Different solutions were used at each site.

Background

Aspidistra, to use its wartime code name, was commissioned by the Political Warfare Executive, PWE, and was established in a purpose-built, or should that be ''dug'', rather large hole-in-the-ground at King's Standing in the Ashdown Forest, near Crowborough, Sussex. The PWE engineering supremo was Harold Robin and it was he who visited the USA in 1940 to buy, for £111,801 4s 10d, a 'surplus' RCA 500 kW MF transmitter that had been built at the request of a US commercial broadcaster. The transmitter was for sale because its original owner discovered that a licence could not be obtained, as the maximum US power limit was fixed at 50 kW (as it still is today).

It is said that Winston Churchill personally authorised the purchase of the RCA transmitter, and when told of it's immense power and ability to wave-change quickly, called it a 'Raiding Dreadnought of the Ether'.

The PWE, and particularly broadcaster Sefton Delmar, wished to use Aspidistra for propaganda in its most devious forms, and a powerful sender that could intrude on enemy wavelengths and transmit misleading information, was just what they required.

A new kid on the block

The BBC, as you would expect, were annoyed that there was 'another broadcaster in town', particularly one with a 500 kW sender, and for a while an uneasy peace existed as Aspidistra was made available to the BBC for ''normal'' Foreign Service transmissions at certain times, with the PWE using it outside those times. Not to be outdone, the BBC planned, and built, their own high-power station, OSE5, at a site east of Hull, near the village of Ottringham, which was arguably superior technically. For a direct, over-the-sea, low ground wave attenuation path to the Third Reich and beyond, this was a good choice.

Concerns were raised that the above-ground buildings could be the subject of enemy bombing, so the four 200 kW transmitters were all in hardened bunkers with a separate control bunker, separate combining house, and a separate power generation house. The site plan is shown in figure 1.

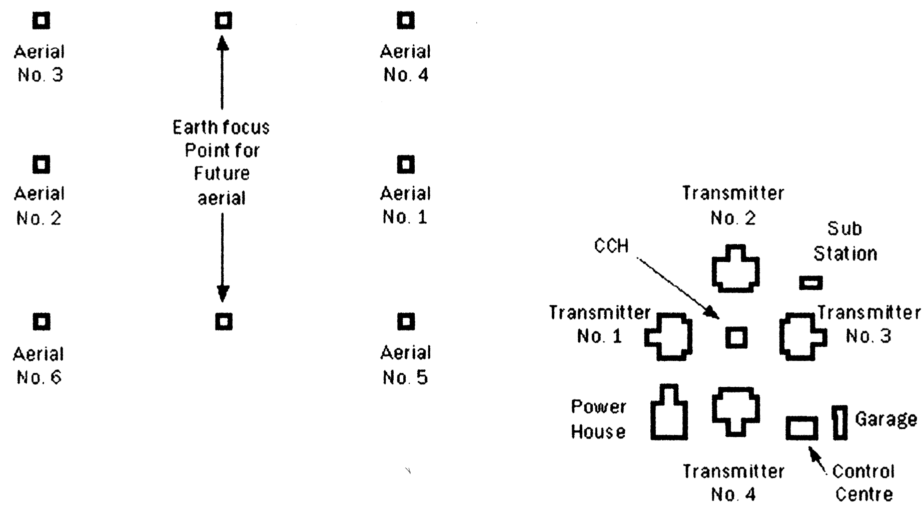

Figure 1. Ottringham site plan. CCH stands for 'Central Combining House'

RCA *vs* Marconi engineering

The RCA transmitter comprised three 170 kW units that were combined to produce 500 kW. In actual fact, it was possible to over-run them slightly to achieve the 'magic' 600 kW. The three units were positioned in a line in a common transmitter hall. The antenna system was a three-mast array, each 110 m tall, with the driven radiator immediately above the transmitter hall and Antenna Tuning Unit, ATU. The driven mast was in front of two parasitic masts, which were off to each side behind the driven mast; there was an ATU below each parasitic mast.

The BBC specified Marconi transmitters that could work on both LF and MF and, indeed, they came equipped with switched inductor and capacitor banks in each transmitter to allow a changeover. At OSE5, the Marconi units were nominally 150 kW, again over-run, well there was a war on! An output of 200 kW was obtainable with a slight increase in audio distortion (approaching 100% modulation) over the 150 kW design level.

The RCA and Marconi systems differed in the concept of their operation; PWE were looking for a system that could change frequency very quickly, whereas the BBC was looking for 'normal' fixed frequency operation with 600 kW on 200 kHz LF and, for example, 200 kW on 977 kHz MF.

Aspidistra: frequency changing and combining

Some careful thought was required to enact a 'Raiding Dreadnought'. One of the authors (DP) is indebted to fellow VT Communications' colleague, Andy Matheson, G3ZYP who, as a former employee of Her Majesty's Communication Centre at Crowborough (as Aspidistra was referred to by the 1960's), was able to describe how these requirements were effected.

Some 15 minutes prior to the time scheduled for the frequency change, one of the 200 kW units would be switched off, and a small retune performed on the combining circuits of the remaining pair of transmitters. The unit which had been shut down would be wave-changed manually to the new frequency. At the scheduled time, the remaining pair of transmitters would be taken off air, and the single unit would take the new service. Then the others would be frequency changed and powered up to join the new service, until full power was realised. The ATUs for the driven mast and parasitic reflectors had manually operated switches that could select, on cue, an alternative set of tuning components.

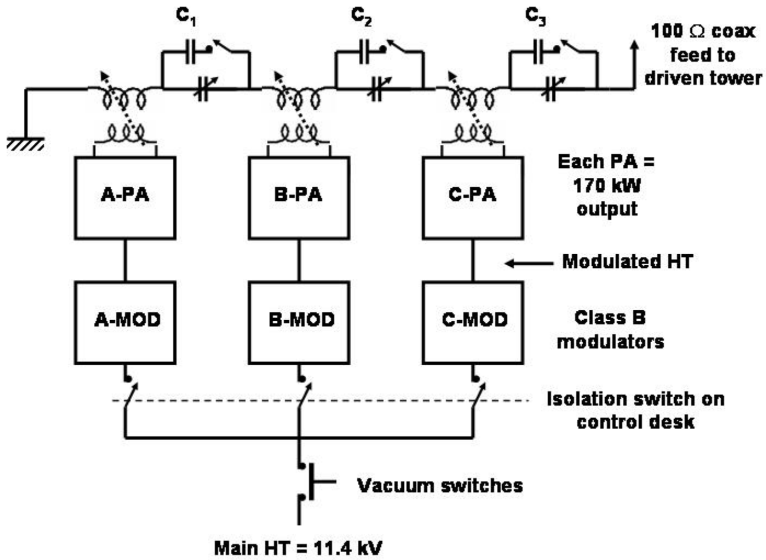

Figure 2. The Aspidistra combining system. Capacitors C_1, C_2, and C_3 are added for frequencies below 700 kHz

Earlier mention has been made of the combining system. The RCA system used a series arrangement where the (up-to-three) outputs could be coupled together. Figure 2, produced by G3ZYP, shows the three PA units with the outputs in series between earth and the inner of the output 100 Ω coax feed to the driven mast ATU.

Andy relates that, with all three units on, the 'R' value into which each PA stage was tuned was 33 Ω. and the series J term was about 70 Ω. When two were in use then the R term was adjusted for 50 Ω, again with a J term of 70 Ω. To carry out the adjustments, the console (control desk) operators performed the HT switching, whilst the transmitter operators used motorised tuning controls on front of (up to three) Aspidistra units for coupling and tune. If only one transmitter was in use, they would tune/ couple for 100 Ω output, and have a J term of about 100 Ω, essentially to get a bit more coil in the act!

For a 500 kW service, the HT would be 11.4 kV and loaded, by varying the coupling, to 20 A on each unit, representing about 228 kW DC input power. Assuming a PA efficiency of 74% the RF output was 170 kW per unit.

To go from the two unit operation to three unit operation, after a frequency change, the loading would be adjusted by reducing the coupling, so that each transmitter unit draws 16A. Thus, the third transmitter unit would have its coupling coil in the correct position to that of the existing units, the HT would be taken off, the Isolation switch operated to select the new unit, and the HT reapplied followed by a quick retune, and re-couple to 20A for all units.

Ottringham: Combining

At Ottringham, the approach was entirely different in that the outputs were **paralleled** by direct connection to a common point, with RF contactor switching to isolate a unit in the event that it became faulty. This approach was not for the faint-hearted, and fail-safe precautions were implemented to prevent a working 200 kW transmitter from powering into a 'dead' one.

To get the picture, imagine just a pair of LF/MF 200 kW transmitters. Individually, they would work into a 300 Ω transmission line. When the two outputs are connected in parallel, they would need to ''see'' 150 Ω. To begin, each unit would be tuned individually into a 300 Ω test load. Thus, when both had been tuned, then they could be switched together to the 150 Ω line.

For 600 kW, three transmitter units would be connected in parallel, and the load would need to be 100 Ω. For four units at 800 kW, the load is 75 Ω. A power of 800 kW on LF was apparently only ever run on test and not on programme service.

At OSE5, four combinations of L-networks were available to select the impedance. The switching for a simpler two-unit, 400 kW system is shown as Figure 3, to illustrate the principle of operation.

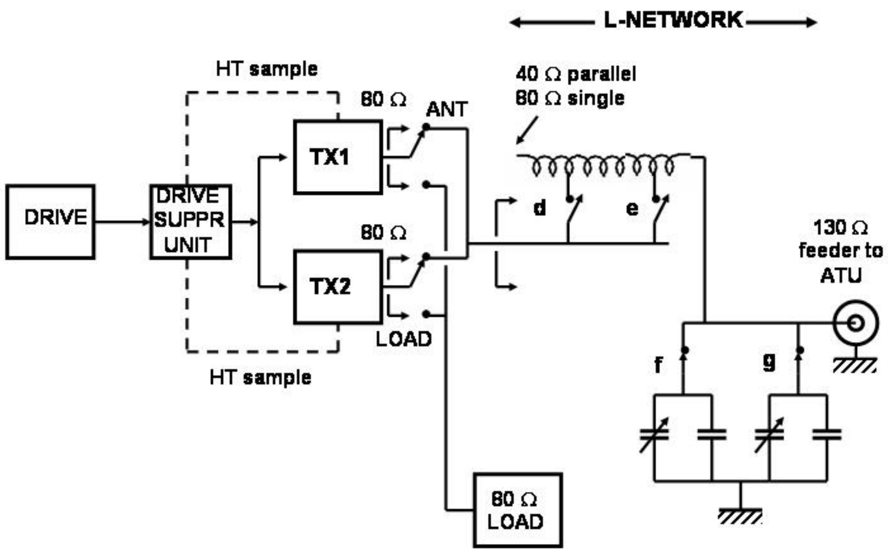

Figure 3. Simplified diagram of paralleling at Droitwich using transmitters with 80 Ω output. The L-network is switched for either 80 Ω to 130 Ω transfer (one transmitter) or 40 Ω to 130 Ω transfer (two transmitters). For paralleled operation, e, f, and g are closed; for single transmitter operation, d and f are closed.

This was the arrangement at Droitwich from 1941 until 1945 for the prototype first paralleled system on 261 m, 1149 kHz at 400 kW called HPMW, (High Power Medium Wave).

Equal phase and power

To ensure that the combined outputs add at the common point, it is crucial that the transmitters are set to deliver equal power outputs that have both RF and modulation in phase; otherwise demodulation and distortion would occur. This requirement is pertinent to all methods of combining transmitter outputs.

High reverse polarity voltages

With the failure of one of the paralleled units, it is necessary to cut the drive to the remaining good units to prevent power being fed into the incorrect terminating impedance and, as mentioned previously, the output stages of the ''dead'' transmitter. If this were allowed to happen, the output valves of the faulty unit rectify the RF and set up reverse voltages across the EHT smoothing circuits, and so cause them to charge up to full peak voltage.

Thus, a Drive Suppressor Unit, DSU, is employed to control the drive to all the paralleled transmitters.

The Drive Suppressor Unit

This has one stage for each transmitter with its HT supply derived from each of the main transmitter HT supplies *via* a resistor network potential divider. Failure of any one transmitter EHT supply causes ALL the drives to be cut. To restore the service it is necessary to open the RF output contactor of the faulty unit, switch the RF contactors in the matching circuit to provide the new, correct impedance for the good unit(s), and switch a local internal HT supply to the DSU to cover for the dead one, to allow drive to pass through to the remaining transmitters.

Where high level class B modulation is employed, it is imperative to cut modulation to ALL units, when drive is suppressed, as dangerous peaks of voltage can be generated across the unloaded modulation transformers. The easiest way to effect this is to use a relay in the grid circuit of the final stage and, when drive-derived grid current is flowing, then modulation is allowed to pass.

Flawed systems

The above OSE5 system is operationally flawed in that constant staffed supervision is required and both scheduled and unscheduled switching operations cause breaks in transmission. With reference to Aspidistra, again a break in transmission is required to effect power changes, so it is also flawed.

What was required is a system where a failure of units neither causes a break nor leads to power being fed into the dead unit. In addition, changes to power output, etc., should be possible without having to endure breaks in transmission.

Effectively, the transmitters need to ''see'' always a correct load but never ''each other''. These requirements led to a different system being researched and eventually invented.

MWT triumph

In 1951, Hugh F Bartlett, a Marconi broadcast engineer, was the inventor and designer of a high power multi-input combiner that was so neat and component efficient, it became the subject of a UK patent.

The BBC, for lower power, also developed a ferrite-cored combiner. In addition, a BBC transmitter engineer, JH Willis, developed in the early 1970's, a different arrangement of Bartlett's combiner that made it even more technically attractive.

Whilst the BBC were busy on this, the HMGCC/ Diplomatic Wireless Service, and later CED, Communications Engineering Dept of the Foreign and Commonwealth Office, were designing a 500 kW system with two 250 kW Doherty transmitters and coupled antennas. All these will be described next time in ToTT.

Andy G3ZYP, spurred on by this latest research, is hoping to be able to present a further article for Signal readers about the other senders in use at Crowborough, as well as add more detail to the engineering of Aspidistra.

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