Tricks of the Trade

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As promised in the last ToTT, we continue to explore more MF Directional Antennas, DA. The overall description of the IBA Saffron Green installation that serves London was outlined in the last article **[1]**; now it is pertinent to see how the setting-to-work was accomplished. Luckily for the IBA MF Unit, they had commissioned, with the help of the US Consultants, similar four-mast directional arrays at, for example, Manchester, Glasgow and Birmingham though, of course, at the time these were only single-frequency installations and the experience gained on those would have been useful. Saffron Green, having two services, both directional and with nulls for each service in different directions and at high power (30 kW and 5.5 kW), was the most complex. A document from the IBA Engineering Information Department **[2]** described the installation but, more importantly for us now, the problems encountered.

Re-radiation problems

DAs impose restraints upon the size and orientation of suitable sites and, in any urban environment, there may be very little choice as to their locations. Consequently, it is probable that any chosen site will be close to other re-radiating structures such as tall buildings or electricity supply pylons.

At Saffron Green, the site was adjacent to two lines of pylons to the north and east, the pylons being of various heights between 27 m and 32 m and about 500 m at their closest approach. The situation was complicated by the presence of a 24 m steel tower at a distance of 700 m in front of the antenna in the main lobe.

Previous IBA DA installations had been subject to signal reflections from pylons but the London case was the most severe. In addition, pattern specifications at two frequencies had to be met. In the USA, pylon detuning at single frequencies is often undertaken in collaboration with the power companies and is a very time-consuming process. So, for this site, investigation was made with a view to avoid pylon detuning.

First steps

The first step was a computer study of the probable effects at two frequencies (1151 kHz and 1546 kHz). The mutual coupling between the antenna and the nearest 27 pylons and the tower was calculated by using, for simplicity, theoretical DA patterns of the antenna and assuming that all pylons were of the same height. The radiation patterns from this giant array of 32 radiating sources, including the four radiating masts, were then computed; the radiation was assumed to emanate from the vertical pylon structures and not from the horizontal conductors.

It revealed the magnitude of base self-impedance of the pylons as being between 200–300 Ω depending on frequency. The phase angle of this impedance was uncertain, so several phase conditions were modelled to assess the impact on groundwave and skywave radiation. The results showed that, regardless of the phase of the re-radiated energy, the resulting antenna patterns in the null regions would be broken by as many as a dozen narrow lobes at both frequencies. This afforded insight into the probable limitations in the angular areas over which nulls at specified depths in the groundwave and skywave patterns could be established. Calculated patterns for the edges of the audio bandwidth were also made.

Result

The predictions showed that, despite the pylons, the pattern bandwidth problem would be negligible and the required null depths could be obtained without detuning the pylons.

Antenna commissioning

The objective was to find the minimum back-lobe levels achievable without detuning any pylons. At 1546 kHz, null levels relative to the main lobe of –23 dB towards Bristol and –17 dB towards other co-channel sites within the arc 315–350° were achieved though further improvement presented difficulty.

At the lower frequency of 1151 kHz, levels of –23 dB were initially obtained within the arc 300–350°. However, it was critical that, within the arc 301–306° towards Birmingham, a level of –24 dB be established. By further adjustments of the antenna mast currents, a null of –35 dB towards central Birmingham and –24 dB at the extreme edges of the arc could be generated.

On the ground measurements

To measure the groundwave patterns, field strength was plotted against range on 16 bearings, at ranges typically from 1 km to 20 km. This necessitated measurements at about 240 locations. To obtain valid information about the depths of the nulls within the arc 260–350°, measurements were made at ranges of at least 10 km, *i.e*. at selected points ten times further from the antenna than those pylons which contributed in part to any re-radiation. The Birmingham null was investigated as far as the city itself at a distance of 145 km. The measured patterns are shown in **Figure 1**.

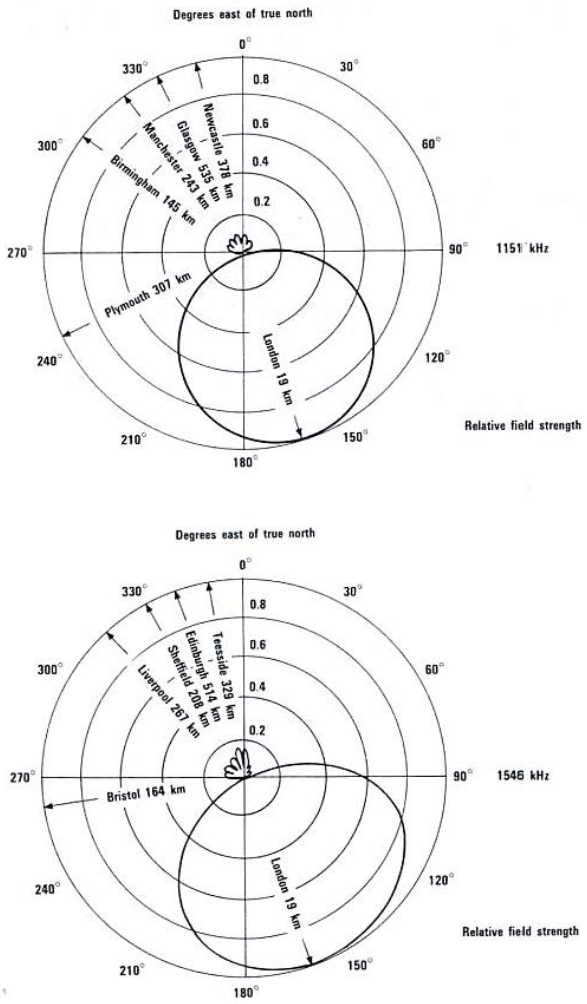


Figure 1. Measured radiation patterns at 1151 kHz and 1546 kHz

Antenna maintenance

Antenna maintenance was mentioned last time but is worthy of more explanation.

The services operate 24 hours per day and so the policy for routine maintenance is to have a reserve mode of transmission that is, as far as possible, independent of the electrical and mechanical structure of the array.

The reserve antenna consists of a twin-wire radiator sloping at 45° from the top of the south mast on its south side. Erection of the antenna takes only a few minutes during which time the transmissions are interrupted.

The bases of the four masts are then earthed and the wire radiator is fed at its base *via* independent coaxial feeders and a dedicated matching/combining network within a dedicated ATU.

The masts act as passive reflectors resulting in the production of broad cardioid patterns towards London. The transmitter powers are reduced to 10 kW from 30 kW and to 4 kW from 5.5 kW, with the result that the co-channel protection to the north and west and the ERP to the south are degraded by no more than 10 dB. Most of the 3 mV/m service contour drops to a 1 mV/m contour, although some areas near the sides of the main lobe are unaffected as the cardioid lobes are larger.

Much was made by the IBA of the resilience of the services from Saffron Green with a triplexed set for 1546 kHz and a main/reserve combination for 1151 kHz but, as reported by the contributors to the mb21 website **[3]** the following happened:-

On the evening of 1st July 1985, a serious fire occurred at Saffron Green. Originating in the transformers of the reserve transmitter for LBC, the fire spread and affected other parts of the building and resulted in the loss of the AM service from Capital Radio. IBA maintenance staff worked throughout the night and had restored both services by 0600 the following morning. The extensive damage to the building meant that transportable radio transmitters had to be brought to the site and special measures taken against chemical hazards. Permanent replacements for the LBC transmitters were due to be installed in April 1986 **[2]**.

In The (broadcast) Trade, we were aware that there had been a fire but the reason for it had not been publicly communicated. However, with the words “special measures taken against chemical hazards” and the fact that just a few months later we (in the BBC) were tasked with replacing certain, identified, oil-filled HV smoothing capacitors that contained polychlorinatedbiphenyls PCBs one can guess as to the most likely prompt for that (expensive) action. Components with PCBs and fire are not a good combination.

The IBA Manchester MF service

The IBA Manchester MF service was one of the first DAs as commissioned by the IBA and was for 1151 kHz. It was at Ashton-under-Lyne and was in service from November 1973. Again there are four guyed lattice masts, all 234 feet high and arranged as an end-fire array aimed at 250° ETN to cover the city about 5 miles to the west. Electrically, the masts are just over λ/4 at 1151 kHz. The masts are neither quite in a straight line nor are they equally spaced. These intended small deviations from a symmetrical array give rise to asymmetry in the null regions of the radiation pattern. In the south towards Birmingham, a deep null is created whereas to the north the null is filled in to provide a programme service at close range. Care was taken to provide nulls in skywave towards Birmingham, Tyne/Wear, Glasgow and London.

Birmingham protection at –26 dB was paramount *via* groundwave and computer analysis predicted a transmitter output power requirement of between 700 W and 1 kW to achieve the specified ERP of 4 kW on the main lobe. Later measurements confirmed they had achieved the –26 dB and that there was 3 dB in hand before that level of null radiation would have been a problem. The critical field strength of 54 µV/m occurred some 40 miles from the Manchester antenna and 30 miles from Birmingham, so – no problem.

Obviously much time, money and effort was spent on this installation and later at Saffron Green to protect Birmingham. Since 30th June 2020, there is no need to be concerned as the 1152 kHz Langley Mill service is no more having been closed down.

In the Midlands

Reference was made last time to the inhabitants of ‘The Zoo’ at BBC Sutton Coldfield. The author is indebted to

Ray Cooper who was a former Senior Transmitter Engineer at this site. Ray has written up a published history **[4]** of the station and has been most gracious in permitting his piece to be reproduced in *Signal*. Consideration was given to abridging this piece to cover just the unwelcome occupant but Ray's style of writing and the recollections he relates are deserving of a wider audience so it is here in full. It has been edited slightly to be in the regular format for Signal.

Ray writes:-

More on BBC local radio

Local radio was no new thing to the BBC; when broadcasting started in this country; all radio was effectively local since there were no networking facilities in position. However, latter-day local radio broadcasting commenced with the opening of Radio Leicester, on a fairly low power as an FM service. This pilot scheme proving successful, further low-power stations were set up and eventually the focus moved on to the 'big cities' – London, Birmingham, Manchester and others. These areas would need rather more powerful installations to cover the required area but, eventually, money and (rather grudging) Government approval was obtained for them.

Cold feet

There was a story, then current, that at one point the Government got cold feet about the project and was wobbling about withdrawing permission. In order to bypass this possibility, the BBC decided on a *fait accompli to* get them in and working before the Government changed its mind. To this end, a number of transmitters were actually flown in by air-freight from the USA since no British manufacturers could provide the goods off-the-shelf. The stratagem worked, though the installations were rudimentary indeed.

The Buzz Factories

Sutton was to be host to two of these new sites; Radio Birmingham as it was then called (it later became Radio WM when the West Midlands conurbation came into being) and Radio Derby. The entire operation was conducted on a shoestring and had to be done from existing sites. Sutton was fine for Radio Birmingham, but much too far from Derby to give a really good service there. Derby itself is in a river valley and shielded from Sutton and field strengths, particularly in the city centre where the studios were located, were low. Listeners here were troubled with all sorts of interference and Sutton became known jocularly by the station announcers as "The Buzz Factory".

In later years, a small 10 W relay was installed at the studios themselves, purely to cover the city centre. This situation persisted until the late-1990s, when a new site for Radio Derby FM became available at Drum Hill, just to the north of the city.

The new transmitters supplied were Gates 1 kW units, a variant of their FM-1 series that used an all solid-state driver feeding a single tetrode amplifier valve. They were in the typical American style; over there, local radio transmitters are just a box that you place into a corner of the studio control room and then forget.

Ease of use

The new transmitters were made as simple to operate as possible; indeed, they had few operational controls; "Plate On" and "Plate Off" push-buttons and a paddle switch labelled "Raise" and "Lower"; this operated the output coupling loop so as to alter the output power. The Eimac valve was driven in such a manner that it was almost impossible to damage by mis-tuning.

Maintenance and troubleshooting was intended to be done by an outside firm of contracting specialists, not studio staff. This being the case, no access to the 'innards' was encouraged and the back door of the unit was firmly screwed shut. This didn't suit BBC methods, so an immediate modification was to remove the screws and install a rear-door Castell-key locking system, interlocked to the mains supply isolator. A small earthing wand was also provided.

Antennas

Antenna installations were quite simple. Radio Birmingham had four tiers comprising two sets of Yagis per level, horizontally polarised and pointing west and south, covering Birmingham to Wolverhampton. The Radio Derby set-up was even simpler: two tiers of one Yagi per level, pointing rather east of north and covering Derby and Burton-on-Trent. (Burton was not actually within the editorial area, being in Staffordshire, but there was no way of avoiding covering it, so its citizens were treated as honorary Derby residents and included in news broadcasts. When the site move to the Drum Hill was made, coverage in Burton suffered and there were complaints). Interestingly, the Derby antennas were mounted with their elements at 45° to the horizontal, thus producing one of the first mixed-polarisation stations, though in those days they called it 'slant' polarisation.

On the cheap

In use, the transmitters were very reliable although, in the early days, the monitoring was extremely sketchy. It consisted in fact of a set of lamps on the manned control desk, basically indicating whether programme input *via* landline from the studios and RF output (from the transmitter) were normal. Monitoring the outputs had to be done on a Hacker portable radio; Hacker in those days meant a respected set maker, not a 'dodgy' Prime Minister nor an antisocial web user.

Eventually, a set of spares for the equipment arrived. I was particularly bemused by one item, a spare inductor. The packet contained a straight length of copper wire, plus a slip of paper saying "Wind this round the shank of a quarter-inch twist drill to make a coil of ten turns, one inch long". I wonder how much it cost to fly that across the Atlantic?

Lack of an audience

Local radio was a little unusual in opening on FM only. Listeners on that band in those days were not great in number and the studios were continually complaining that what they needed was a medium-wave outlet. Eventually, they were given one, though again it was all done at minimum cost.

The Zoo and its most unwelcome occupant

In the case of Radio Birmingham, there was a 'lash-up' consisting of a Marconi B6029 10 kW AM transmitter installed in a corridor, 'The Zoo' which initially fed, at 5 kW, a sloping-wire antenna supported from the main mast. This wire passed directly over the main transmitter block and was a deep embarrassment from the start. The field strength inside the building was enormous and Radio Birmingham on 1457 kHz found its way into most of the programme distribution amplifiers, being both heard and seen.

The partial taming of The Beast in The Zoo

To overcome this another arrangement was speedily devised; the wire aerial was removed and the transmitter, still at 5 kW, now fed a couple of 150-foot pole radiators down in one of the surrounding fields. The mast base pads were made from railway sleepers and the ATHs (Aerial Tuning Huts) from tiny fibreglass shelters of the kind then used by road works night watchmen.

The Sutton MF DA

The poles were driven with a suitable combination of power and phase so as to produce a main lobe pointing at Birmingham, with two deep nulls centred on London and Manchester, which were using the same frequency. Cunningly, the masts were sited in such a position that the London null also coincided with the main television mast. This was done so that the TV mast would not reflect or re-radiate any of the signal and so spoil the radiation pattern. Unfortunately, the signal could not be kept off the mast stays, and these re-radiated with abandon. This upset the performance of the installation somewhat. Field strengths inside the building were now lower, but still high enough to make fault-finding using sensitive measuring gear a misery.

Normality ensues...

Eventually, another site became available when Independent Local Radio started up from IBA Langley Mill and, to everyone's relief, this was used instead and the temporary setup at Sutton was torn down.

Ray's piece ends.

Thanks to Ray for those revelations about The Beast and the quick set-up of BBC LR. Sutton Coldfield SC was not alone in this as the author can recall while at Holme Moss seeing three local radio FM transmitters, again Gates types, as at SC, for Radio Leeds, Radio Manchester and Radio Sheffield. All three services are still broadcast from there albeit with additional local relays now.

Radio Derby's transmitter in The Zoo was actually on-air before the start of the LR studio service and was fed temporarily with BBC Radio 1; reception in Daventry, miles out of the intended service area was excellent.

The IBA Birmingham service and joiners

Ray mentioned that peace was restored in The Zoo after the transfer out of the BBC LR MF service. It went to IBA Langley Mill on the NW side of the city. All that remained in The Zoo were the pair of Gates FM transmitters.

Since March 1973, there had been a standard four-mast in-line array for the IBA as at Manchester with a single frequency service on 1151 kHz, with protections in place for London, Manchester, *etc*. The addition of the second frequency on a site-share would have been a major task as the work would have had to be done at night, out of major programme hours, to engineer new ATU components and resolve the phasings and nulls. Obviously the ILR nulls on 1151 kHz stayed the same but new ones on the BBC 1457 kHz frequency were also required for Manchester and London.

At the beginning of 1995, it was announced that a new service was to be on site, called Radio XL and it was on 1296 kHz; thought was given to yet more work on the array as it too was to be directional towards Birmingham. Luckily common-sense prevailed and a great deal of work was avoided as a new mast and simple sloping wire reflector was erected on site as far as possible away from the others to give a EMRP of 10 kW on 235°.

The B6029

Mention was made last time of the Marconi B6023 transmitter, *aka* "The One Kilowatt Noise Box" with the single triode output stage linearly amplifying up from 15 W modulated input to the 1 kW level. The 10 kW B6029, as used by the IBA and BBC, was very similar and just as inefficient in percentage terms. The major difference was that an air-cooled tetrode STC/ITT type 4JC301J was in the Class A/B linear final but with far more stage gain (tetrode *vs* triode) to get from the 15 W to 10 kW.

The 4JC301J, when used in the BBC-designed and produced Doherty transmitter, could give 50 kW output in the carrier slot with another 4JC301J in the peaking slot to provide the positive peaks.

Compared to the B6023 the noise from the fans and internal ducting in the B6029 was no worse, even though up to 40 kW of waste heat was being removed.

Reference **[5]** is to a Marconi sales document and contains the full specification for the B6029 (**Figure 2**).

The author was probably a little unkind in the last ToTT where mention was made of the sheer amount of noise from the B6023 and implied that the British Organ Blowing Co. (BOB) fan was to blame; well, actually it wasn't, it was just doing its own (quiet) job but the ducting design and air enclosure in the transmitter were the noise generating elements. After all, BOB fans are used in churches!

Take your pick:-50 Ω or almost infinity!

The author was also reminded by a retired BBC antenna engineer of an incident at BBC Trowell that served Nottingham. Here, the IBA and the BBC each had a separate room in the building, each with a B6023. Planned antenna work had been conducted and the antenna engineer had disconnected both input coaxial feeders to the combining unit for BBC 1521 kHz and IBA 999 kHz presumably to take measurements and match for 50 Ω on both channels.

10kW M.F Broadcasting Transmitter Type B6029

Features

Only one valve, type 4JC301J.

Solid state drive, type B 6002 (see page 164).

High reliability, silicon rectifiers, no moving r.f contacts, single tuning control.

Minimal floor area with no rear access required.

Simple installation, no external items.

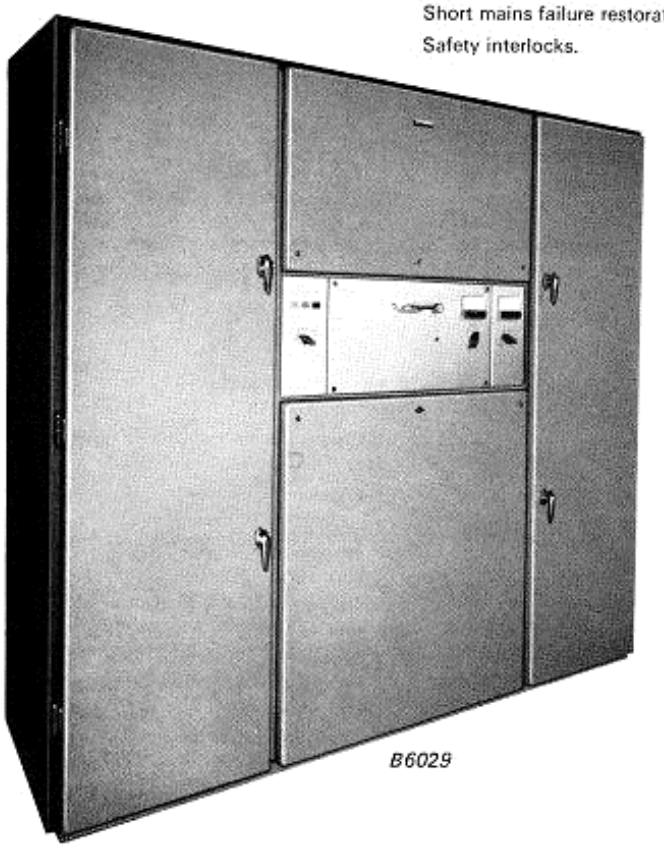
Accepts high modulation level (drive inherently self limiting).

Air-cooled.

Overload protection incorporates safe-guard against transient fault operation.

Short mains failure restoration circuit.

Safety interlocks.



B6029

Data summary

Power output (at nominal mains voltage): 10kW carrier.

Working frequency in range: 525 to 1605kHz.

Output impedance: 50Ω unbalanced (Max. v.s.w.r 1·4:1).

Modulation rating: 100% continuously.

Carrier amplitude shift: Less than 5% at 100% modulation.

Frequency stability: ±10Hz per month standard (precision drive extra).

R.F Harmonic and spurious content: Less than 50mW.

R.F Noise level: −60dB unweighted, relative to 100% modulation.

A.F Response: ±1·0dB, 30 to 10,000Hz relative to 400Hz.

A.F harmonic distortion: Less than 3% at 75% modulation, 30 to 10,000Hz.

A.F input for 100% modulation: 10dBm into 600Ω.

Power consumption: Less than 45kW at all modulation levels.

Power factor: 0·9.

Supply voltage: 380–440 ±4% 3ph.

Supply frequency: 50 or 60Hz.

Ambient temperature range: 0–40°C.

Dimensions:

Height	2·16m	(7ft 1in.)
Width	2·29m	(7ft 6in.)
Depth	0·81m	(2ft 8in.)

Full details are given in TD B 6029.

Figure 2. B6029 transmitter specifications

Prior to resumption, the feeders were connected and services re-powered to antenna *via* the combiner. After a few minutes the IBA engineer leisurely wandered through to the BBC area and commented that their transmitter meter readings now looked a little different but most likely it was OK. The BBC antenna engineer checked and agreed, but decided to check at the combiner. He immediately noticed that the IBA feeder was still disconnected, just lying on the floor and that the Delta Inc. RF measuring bridge was still in the IBA inlet port.

There was a quick shout through the common area to the IBA to turn off their service followed by the test gear removal and correct reconnection then a shout of “try it now”. All was now confirmed normal on the 999 kHz B6023. It was a tame machine and not a VSWR trip in sight. Whether the BBC antenna engineer confessed is not documented!

Next time

Away from the heady expense of multi-masted arrays with all their phasing and power-splitting requirements we will investigate the sloping wire reflectors for more economical DAs.

References

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