Ambisonics-Soundfield Experience

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This year, the BBC took delivery of two Calrec *Soundfield Mk III* (production model) microphones. Prior to this, however, the BBC had already assessed the prototype *Mk II* microphone. Richard Elen describes the BBC's experiences with this novel microphone system, described by some as "the most important microphone development since Blumlein".

IT IS perhaps unfortunate that the prototype Calrec *Soundfield* mic didn't make its appearance on the BBC scene until after the first run of *Matrix-H* and *HJ* experimental surround-sound broadcasts had been completed. It is hoped that transmissions in the latter format will start again soon, and will no doubt make use of the *Soundfield* mic, but in the meantime, BBC Studio Managers and researchers are amassing a good deal of information on the performance of the mic in stereo applications, which will obviously be a great deal of use when surround broadcasts are continued. The IBA has also completed its first set of broadcast evaluations of the Ambisonic technique, deciding that a 3-channel Ambisonic transmission format is to be preferred to a 2 or 2½-channel format. The 3-channel system has certain technical problems associated with it, but these will no doubt be overcome, and with favourable reaction to Ambisonics from the EBU and FCC it may well be that this innovative British-designed system will form the basis of the record and broadcast output of the future. Of course, the technical difficulty of transmitting or cutting three or more channels of information disappears when we consider digital multiplex encode/decode techniques; even before this, however, it is likely that analogue methods will be devised to cope satisfactorily with the three channels required for 'horizontal' surround-sound, or the four channels needed for full 'with-height' reproduction.

In the meantime, however, it's well worth looking at the BBC's experience with the *Soundfield* microphone, because apart from the *UHJ* surround-sound possibilities of this mic, it promises a great deal in terms of stereo flexibility and response. To find out more about the BBC's work in this field, I discussed the system with Bob Harrison, from the Assistant Chief Engineer's department, Radio Broadcasting, and Antony Askew, who is a Senior Music Studio Manager. Bob Harrison's role enables him to experiment a fair amount with new techniques without being so far removed from actual operational situations as to be unable to relate his findings to the limitations of broadcasting requirements. Tony Askew, on the other hand, is frequently responsible for 'driving' the entire mixing system at major 'serious music' events like the Promenade Concerts, where the *Soundfield* mic has been employed over the last two seasons. Without doubt, the BBC has been in an excellent position to evaluate and apply the *Soundfield* mic 'in the field'. This process of extended and meticulous investigation is still continuing, of course, but already some firm results have been emerging.

In fact, the story of the BBC's involvement with mic techniques of the *Soundfield* type goes back to 1976, when the late Ben Bauer brought a prototype *Ghent* microphone over from the States for the BBC to examine. The *Ghent* mic is specifically designed to offer exact encoding to the Columbia *SQ* 'quadraphonic' standard, and part of this specification includes the requirement for the microphone to eliminate phase anomalies, particularly in the front quadrant. Phase—and frequency response—anomalies are a big problem in mic systems which make use of Blumlein and other coincident pair techniques, as used extensively for BBC music productions: with two discrete microphones it is theoretically impossible for the pair to exhibit full phase coherence over the entire audio range, resulting in problems with image location as the sound wavelength approaches the distance between the capsules of the array. The *Ghent* mic was designed to correct such anomalies—at least in the front quadrant—and thus it was expected that it would perform well in stereo configuration. This indeed proved to be the case at an Albert Hall test: the stereo imaging was excellent and the general 'cleanness' of the sound was very encouraging. At the very least it showed that the idea of developing a microphone without phase and frequency-response anomalies had a very good chance of success. However, the *Ghent* mic had the disadvantage of offering no variation of polar response characteristics; good results were thus largely dependent on finding exactly the right position and orientation in a hall, and this was very hard to attain. But the system showed promise.

The arrival of a *MkII* prototype *Soundfield* mic around the middle of 1978 enabled operational research in this direction to proceed a good deal further. It was first utilised in the recording of the last concert from the Cheltenham Festival in July 1978 with the BBC Symphony Orchestra. The mic was positioned about 8-10ft from stage level at a point which provided a good musical balance of the

A special mixer installed in the IBA's mobile which includes five special surround sound channels

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orchestra and the derived stereo output from the control unit was monitored. At first hearing the results were not very rewarding. The overall sound balance so close to the audience on a hot sticky July evening was dry and lifeless. Even so, the clarity and precision of the stereo image produced by the mic was exceptional and definitely supported the claims made for the mic. For the first time, the BBC had a microphone available which, firstly, had a flat response from 40Hz to 10kHz; secondly, all its parameters were variable from a remote position. Equalisation in the microphone produces the effect of 'true coincidence' of the capsules, thus eliminating phase anomalies, and manipulation of the B-format output of the mic's matrixing network enables the operator to adjust the effective physical orientation of the mic, including pan, tilt, and so on at the control unit, or—by recording the B-format Ambisonic signal on four tracks of a multitrack—alter these parameters after the event. Truly an amazing facility. The theory behind the microphone also offered the possibility that a single mic could be used to make perfect 2-channel phase-matrix recordings of the *Matrix-HJ* type — previously, a good *Matrix-HJ* programme had been dependent to a large extent on the manipulation and use of existing stereo techniques: the problem being that it was important to offer a good stereo balance as well as surround sound, and the interaction of conventional BBC stereo mic techniques in a surround-plus-stereo configuration was difficult to predict or set up with any degree of the necessary accuracy without a great deal of effort. The *Soundfield* mic, however, offered the promise of truly compatible surround and stereo decoding: a strong necessity if the BBC experimentation with the *HJ* part of the Ambisonic hierarchy is to continue.

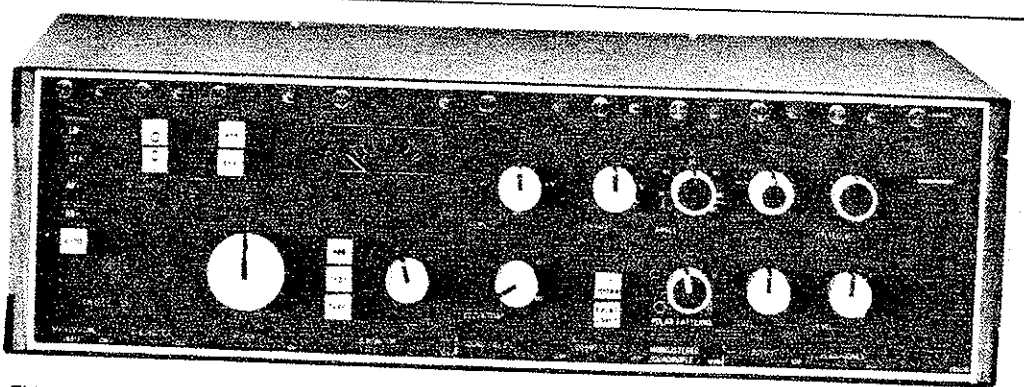
The *Soundfield* prototype was then installed at the Albert Hall for evaluation on a series of Promenade concerts. The version in use at this time—the *MkII* prototype—was fitted with Reading University equaliser and power supply and a prototype Calrec control unit with Reading electronics. Peter Fellgett and his technical designer Jeff Barton took time off to make sure everything was working correctly and reliably. The microphone was placed a little in front of the usual stereo main-pair position, about 15-20ft up and about 3 or 4ft in front of the fountain in the Albert Hall, and it was here that the first major advantage of the Calrec mic to the BBC was demonstrated.

Standard practice for rigging a stereo pair at the Albert Hall requires the dropping of a line over each end of the balcony to haul up a sling arrangement. The mic is centred in the sling and the audio cable is run off along one side of the sling line to the sockets at balcony level. Due to the weight and asymmetry of such an arrangement, it is often the case that the mic array twists as it is raised, necessitating at least half an hour of raising, lowering and correction of position in addition to the hour or more required to set up the sling in the first place. The *Soundfield*, however, took a mere 20 minutes to rig, dangling on its cable from a tightly-stretched sling. Any change of mic attitude could be corrected with ease by adjusting the B-format attitude knobs on the control unit. The BBC's current method of slinging the mic also includes a drawstring to the back of the arena, with the main sling a little further forward than before: this enables front-to-back movement of the mic's physical position to be carried out.

At this stage the mic was, of course, used in stereo only: the derived stereo signal from the control unit was brought up on the mixing console as an external feed, which could be compared in an A-B fashion with the 'conventional' mics and incorporated in the main output if the Studio Manager performing the concert mix so desired. During last year's Prom season, the mic's output was available about 60-70% of the time and was often used in the main mix.

Before discussing the results of this particular series of tests, it's important that we take a brief look at the standard BBC approach to miking up a concert of this type, and the basic premises upon which the 'sound' of a BBC 'serious music' broadcast are based. BBC stereo techniques are currently largely reliant on the Blumlein or coincident pair arrangement, often assembled from discrete microphones. Over the years, BBC sound balancers have built up what we might term an 'acoustic blueprint' of the *type* of 'sound' a music broadcast should have. This attitude, of course, is one that has produced superlative results, and continues to do so. It does mean, however, that impressions of an entirely new system will be based on what such a broadcast *usually* sounds like: this will modify sound balancers' opinions, which are, of course, highly subjective. A further consideration is the fact that venues like the Albert Hall are quite well-known to many radio listeners: they will have attended concerts themselves and will have a fairly good impression of the sort of sound they ought to be hearing. They're also used to BBC broadcasts, and the broadcasts themselves must create the best possible illusion of the sound of the Hall. Indeed, Proms are one of the few examples of a situation in which the listener is actually aware of what the 'original sound' would be, as opposed to a studio recording or broadcast.

The 'broadcast illusion' is to a large extent enhanced by actual *limitations* and 'faults' in conventional microphone design. With a standard setup which depends on one or two main stereo pairs backed up with ambience and solo mics, methods of compensating for the massive change of the Albert Hall acoustic between rehearsal and performance are well-known to BBC sound balancers. This change must not be underestimated: 7,000 people in the Hall have a tendency to remove any ambience picked up naturally by the main pair: ambience mics, with their attendant 'muddying' of the overall sound, must be introduced at relatively high levels into the mix to create the right sound. In these conditions, such effects as 'lobing' on the main pair—where the response of the mics at higher frequencies is rather more directional and peaky —tend to make the resulting output more satisfying to the listener. For example, 'lobing' tends to move a string section outwards from its actual position in the sound-stage to produce a more impressive stereo spread. Hf 'presence' provided by the complex phase cancellations that occur when several stereo pairs are superimposed also tend to brighten up the sound and make it more lively. These effects are almost entirely the result of manufacturers' attempts to compensate for the anomalies in stereo mic design inherent in variable polar diagram capacitor microphone types—methods varying from one maker to another—and as a result of the anomalies themselves. The difference with the *Soundfield* mic is that it does not suffer from these



This photograph shows the current (production model) control unit required to operate the Soundfield *microphone, as used by the BBC. The signal is fed from left to right via the following modules: the mic input module which takes the feeds direct from the mic head ('A-Format') after eq in the body of the mic, and offers individual mutes on the equalised capsule ouputs plus a —20dB A-Format pad; the A-B matrix module which converts the A-Format signals to standard B-Format (X, W, Y, Z outputs corresponding to a front-facing figure-of-eight, omni, left-facing figure-eight and up-facing figure-eight respectively) and offers mic-inversion facilities; the B-Gain module which offers switched control of the B-Format level (+6, +14 and +20dB lift) and a rotary gain-control attenuator; the B-Format monitor module which offers individual PPM monitoring of the B channels plus overall levels; two* Soundfield *modification modules which control azimuth and elevation, and dominance; a mono/stereo/quadruple module which handles the coincidence angle and polar diagram settings; and two output modules, one equipped with Ambisonic decode/loudspeaker layout control and main output level control, the other controlling the stereo-output width and headphone-monitor level. To the far right of the unit is the power-supply module with power-on pushbutton.*

useful but anomalous features. These factors should therefore be borne in mind.

In many ways, the appearance of the *Soundfield* mic came at a good time for the BBC in terms of mic technique. There had previously been a general swing away from a single coincident pair in favour of several superimposed coincident pairs supported by close and distant spaced mics; this move unfortunately coincided with the surround sound experiments, and almost certainly magnified the technical problems of compatibility earlier discussed. But by the time the new mic arrived, there had been a move back to primary dependence on a well placed main stereo pair: as a result it was not too difficult to incorporate the *Soundfield's* output into more traditional setups.

It was expected that the *Soundfield* mic, because of its true coincidence with attendant lack of phase anomalies, and its previously unheard-of flatness of frequency response, would similarly not suffer from the somewhat impressive audio effects such anomalies introduced. This indeed proved to be the case: the mic produced exactly what would be expected from a truly coincident array. Once again there was the excellent stereo imaging: Tony describes it as 'electrifying' and says that things actually sounded for the first time as they did in real life. Acoustic pianos, for example, lacked the usual 'clankiness' which occurs with some microphones. The Studio Manager actually performing the mix is given total autonomy over the type and positions of mics used at these concerts: in the case of the *Soundfield* mic, he also had a free rein in the application of the mic in the mix, making full use of the variable attitude and polar diagram controls.

One surprising feature of the mic in this respect was the fact that the array could be switched to 'omni' without the loss of stereo imaging! This effect is made possible on the *MkIII* production models by means of the addition of a control to vary the degree of effective coincidence of the capsules.

The one problem encountered with the *Soundfield* mic during these experiments was the very fact of its technical accuracy: the lack of 'lobing' and other anomalies tended to produce a very clear, but somewhat dull and unimpressive, sound. This can be compensated for, however, with the use of a rising equalisation curve, adding just a touch of 'sparkle' to produce a result that is psychologically more satisfying, and more like the usual sound that listeners expect.

These experiences with the *MkII* resulted in the BBC placing an order with Calrec for two production models, which were subsequently delivered and used during this year's Prom season. Tests have also been performed with the *MkIII* in control conditions at the BBC's Maida Vale studios, where Studio Managers have been able to experiment with different positions and settings of the mic, and compare it with other types. Initially the power unit on the new modules gave a little trouble, but Calrec rapidly redesigned and eliminated the teething troubles—prevalent in any new item of production. Bob Harrison praises Calrec's avowed keenness to 'get it right'.

In parallel with the Albert Hall evaluations in stereo broadcast configuration, comparison tests were performed by recording the B-format output on four tracks of an 8-track Brenell recorder, placing on the remaining tracks a selection of outputs from conventional stereo pairs. Apart from producing useful Ambisonic demonstration material, these tests provided an opportunity to evaluate the new mic in a number of operating modes on an A-B basis with conventional techniques under control conditions. The tests also proved useful in terms of discovering the general performance of the mic and the best way to interface it with recording equipment. Experiments proved that a level of about 200 nWb/m on tape combined with dbx noise reduction offered a dynamic range in excess of 84dB: it was possible to record an entire concert, with large variations of dynamics and playing levels, without adjusting the gain of the system. Some experimental recordings were also made in B-format on a Teac 4-track, and it is interesting to note that these seem to indicate that the B-format is far more tolerant of tape azimuth errors than a normal-format recording.

Bob and Tony feel that the *Soundfield* is about the best mic they've come across. The variable controls have proved exceptionally useful, the rigging time in a concert situation is very short compared with conventional arrays, and the sound, although a little dull without eq, offers superlative stereo imaging and depth. It offers 'the best sound from any part of the orchestra' that they have found, and the derived stereo signal can be listened to they have found, and the derived stereo signal can be listened to comfortably for long periods without strain. But an ideal mic will not necessarily give an ideal sound in non-ideal conditions—like the average concert broadcast—and certain adjustments, like the addition of a touch of eq, are necessary to produce a suitably satisfying result. The fact that the controls can be, in general, continuously varied during a performance, to optimise the aesthetic parameters of a broadcast or recording, suggests that the mic will have a great deal to contribute to the normal BBC setup at a concert where there may be as many as three separate groups—TV, Radio and the BBC Transcription Service—taking feeds from the main mics. The *Soundfield*'s output can be fed to a separate control unit for each group, so they can each obtain a fully-variable independent main stereo signal without duplicating mics and without affecting the versatility of any of the users' signal feeds. It is the BBC's intention that a second *Soundfield* mic should be tried near the stage, in addition to one in the original position, to provide a versatile output for more 'intimate' miking, where a digital time delay would be employed to bring the output of this mic back into perspective with the main system.

The BBC has very few complaints about the *Soundfield* system: surprisingly few considering the radical new techniques which this mic introduces. It finds that the production model appears to be a couple of dB noisier than the *MkII* prototype for some reason—hopefully Calrec will look into this, as it can't be a fundamental problem. The BBC also finds the azimuth control a little coarse: it would prefer a 4-position quadrant switch plus a pot to alter the azimuth within a quadrant, or perhaps a forwards/backwards switch pointing the mic in one of two positions at 180° to each other, plus a pot to vary the azimuth over the 180° segment, instead of the present continuously rotating 360° azimuth control, which doesn't offer sufficiently accurate positioning or repeatability (although the 360° control could be very useful in rock studios). The BBC is also interested in the *Soundfield*'s possibilities for opera, where a switch to 'position' the mic figuratively 'sideways' in addition to the present vertical inversion control would enable the mic to 'look' at the orchestra pit and stage with equal ease. At present this can be done by cross-patching the X and Z outputs, but a switch would be more convenient. Many operators feel that the dominance control is one of the most useful features of the control unit, but the present control is too coarse in operation, and ought to be replaced by a continuously variable front/back dominance control and an up/down dominance control.

One other slight misgiving with the mic is the fact that it requires a 60V phantom power voltage. The BBC, in common with many broadcasting organisations worldwide, uses a standard DIN voltage level of 48V for phantom power. This is a standing voltage on all BBC mic lines in such places as the Albert Hall, and means that the *Soundfield* mic presently requires its own separate cabling and cannot be plugged into existing lines. This is a disadvantage, and is presumably quite straightforward to rectify.

There is also a slight feeling that the present control unit is over-complex for purely stereo use; abandoning the modular concept to produce a simplified stereo-output-only controller would perhaps make the mic more affordable placing it in the same price range as other condenser mic arrays, although such a version would of course be rather more limiting for Ambisonic productions.

All in all, however, the BBC's opinion of the new Calrec *Soundfield* microphone is very good: it is a very significant development in microphone and audio design which offers great possibilities for current broadcast and other professional requirements and offers even more for the future of sound reproduction as moves continue to bring about the standardisation of a technically successful surround-sound medium: the *UHJ* system. ■

agony

A West London studio session was rained off earlier this year when one of the biggest storms ever to rumble across England passed directly overhead. First the mains voltage dropped so low that the electronic keyboards sank irrevocably out of tune. But this didn't really matter because there was so much static coming down the lightning conductor that the tape was recording more noise and crackles than out-of-tune music. The final piece de resistance, however, came with a bang and a flash directly overhead. En route to earth the high voltage charge produced just the right coded pulse to trigger the remote control 24-track machine into replay. Obediently it lurched into life like furniture under the influence of poltergeists. Wisely the assembled crowd called it a day and fled to the nearest pub. There are some things in this life that you just can't fight.