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INVESTIGATIONS INTO THE USE OF RK LOUDSPEAKERS
FOR STUDIO BALANCING, WITH PARTICULAR REFER-
ENCE TO THE PROBABLE FUTURE USE OF WIDE-RANGE
LOUDSPEAKERS

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INVESTIGATIONS INTO THE USE OF R.K. LOUDSPEAKERS FOR STUDIO BALANCING,
WITH PARTICULAR REFERENCE TO THE PROBABLE FUTURE
USE OF WIDE RANGE LOUDSPEAKERS

SUMMARY

Tests have been made to determine which of the loudspeakers at present in use in the Corporation should be adopted as standard during the period which must elapse before a change can be made to a wide-range type. As a result of these tests, the corrugated cone, internal spider R.K. loudspeaker is recommended for this purpose.

It has also been found that certain of the objectionable effects commonly noticed in wide-range reproduction are due to a microphone technique arrived at through balancing on loudspeakers possessing pronounced low frequency coloration. It appears, moreover, that, given good studio conditions, a balance can be found which will produce acceptable reproduction both on a wide-range loudspeaker and on a good loudspeaker of the older type.

INTRODUCTION

Within the past fifteen years or so, four different kinds of loudspeaker have come into service in the Corporation, which gives rise to some inconsistencies in studio balancing and in monitoring generally. It is expected that improved loudspeakers, having an extended upper frequency range, will ultimately supersede all the present types, but it will probably be a few years before the last of the older units is withdrawn from service. It has therefore been decided to review now the various types of loudspeaker already in use in the Corporation in order to single out the best and to effect some measure of standardisation in the immediate future.

Apart from the Wharfedale "Golden" unit, all the loudspeakers at present in use in the Corporation have been made by the B.T.H. Co. Ltd. The Wharfedale unit was originally chosen for O.B. use, its inferior performance being tolerated on account of its small size and weight, and it is not intended to be used for studio balancing. In what follows, therefore, only the various B.T.H. loudspeakers are considered.

The two B.T.H. units in most common use are both of the Rice-Kellogg type, having corrugated cones, but differing in the form of the centring

spider. In the earlier model, the spider is inside the cone, and is held in place by a single screw tapped into the centre pole of the magnet, while in the later version the spider is outside the cone and is attached to the loudspeaker chassis by three screws. In spite of this apparently unimportant mechanical difference, there is in fact a considerable divergence between the performances of the two types, the reproduction from the ISRK^{*} being "crisp" or "forward" with a tendency to shrillness, and that of the ESRK relatively low toned but with a slightly extended upper register. Although both of these loudspeakers could fairly be described as much better than those fitted to the average commercial receiver up to 1939, neither of them comes into the "wide-range" category. In 1936 the B.T.H. Company introduced a new model having a moulded, uncorrugated cone with a very pronounced flare. This unit gives the impression of an extended high frequency range, and may be described as approaching the "wide-range" category. The performance of this loudspeaker, however, has been found to be so disappointing, on account of a lower middle coloration of the "tunnelly" type, and a "glittery" upper frequency response, that it is already generally agreed^o that the corrugated cone Rice-Kellogg loudspeakers should be used in preference whenever possible. The manufacture of the corrugated cone units was discontinued some time ago, and in view of the present shortage of loudspeakers it is desirable that production shall be resumed as early as possible. It is therefore a matter of some urgency that a choice should be made between the ISRK and ESRK loudspeakers, so that the necessary bulk orders may be placed, and this report is mainly concerned with the manner in which the final decision on this point has been reached.

It will be noticed that all tests herein described are listening tests only, and that no reference is made to any objective measurements made on the loudspeaker concerned. It is our experience that conventional measurements of loudspeaker frequency response are at their best difficult to interpret, and at their worst positively misleading. Some progress has been made in Research Department towards the establishment of objective criteria by transient response measurement (Research Report M.004), but this work was interrupted in 1939 by the outbreak of war, and has not yet been resumed on account of the lack of experimental facilities. The present investigation has therefore been conducted entirely by ear, care being taken however to make no decision without comparison between the original and reproduced sounds.

^{*}As there will be occasion to refer to these two loudspeaker units very frequently throughout this report, the abbreviations ISRK and ESRK will be used to denote respectively the internal- and external-spider models.

^oMeeting held at Nightingale Square on 25-4-45 between representatives of Research, D.I. and S.E.(S) Departments.

In all the tests, the RK loudspeakers were used in the standard baffles LB/3, since the unit chosen would have to work in baffles of this type.

THE PROBLEM

The purpose of the tests now to be described may thus be recapitulated:

1. To decide which of the two corrugated cone B.T.H. units should be used in the Corporation until better loudspeakers become available.
2. In arriving at this decision, to bear in mind the fact that future loudspeakers are likely to cover an increased frequency range, particularly at the upper end of the band, and to see what effect the use of such loudspeakers for monitoring and balancing is likely to have upon the service given to listeners equipped with reproducers of lower grade and vice versa. Other things being equal, the monitoring loudspeaker to be chosen should be that which will give the best service to both classes of listener. The possibility of a little electrical correction in either case was not ruled out. For example, it was thought that the performance of an existing loudspeaker might be improved by adding a gentle slope up to the overall characteristic (such an overall slope has already been advocated by West and McMillan^{*}, who specified 2.5 db per octave for the axial characteristic of the loudspeaker in a particular case).

COMPARISON WITH WIDE-RANGE LOUDSPEAKERS

When this investigation was first commenced, the only wide range loudspeakers available were the Voigt and a number of experimental Barker units. The Voigt loudspeaker suffers from coloration in the lower middle and extreme high frequency range. The Barker units, in their present state of development, suffer from low frequency coloration. Neither of these types was therefore suitable for the present purpose. Later, however, an Altec Lansing loudspeaker became available, and, as this showed good promise, it was taken as representing the type of wide-range reproducer likely to come into use in the future.

^{*}G.P.O. Research Department - "The Design of a Loudspeaker",
Journal I.E.E., May 1940.

EARLY TESTS

Comparative listening tests on IS and ESRK loudspeakers, both in standard LB/3 baffles, were first made at Nightingale Square over a period of some weeks, and covered most types of programme. The results confirmed what was already known in a general way. The ~~ESRK~~ gives a lower pitched and more distant type of reproduction, but has a slightly better response to the extreme high frequencies (probably around 6 - 7 kc/s) than the ~~IS~~ model. The principal faults of the two loudspeakers were lower-middle coloration in the case of the ESRK, and shrillness and hardness of reproduction with the ISRK. Preference fluctuated between the two types of loudspeaker with changes of programme, but it was not possible to draw any universally applicable conclusions.

PEOPLE'S PALACE TESTS

In an endeavour to arrive at a decision, the tests were continued in a listening room at People's Palace, where direct comparison could be made with the original sound. It was soon found, however, that the studio was far from good, and could not be made to yield really satisfactory quality in any circumstances. The effect of this upon the loudspeaker tests was to give a choice of two different reproductions, both of indifferent quality. Electrical equalisation of both loudspeakers was attempted, and when this was done the difference between the two reproductions was found to have been much reduced. The amount of improvement was, however, not great, and the reproduction from both loudspeakers was regarded as unsatisfactory.

At the time that these experiments were beginning, the Altec-Lansing loudspeaker became available, and this was also tried at People's Palace. The reproduction from this was rather bass heavy, cabinet resonance being suspected, and the extended upper frequency range gave very variable effects, sometimes pleasantly realistic and sometimes metallic or "dirty". (It may be mentioned in passing that this latter effect has very frequently been found in the past with all loudspeakers having an extended high frequency range.) As a result, preference fluctuated between the Lansing and the two RK loudspeakers, and it was impossible to come to a firm decision on any of them.

As a result of the foregoing, it was felt that an impasse had been reached, and that the only way out was to use a better studio. The large orchestral studio at Glasgow (Studio 1) was considered to be the best available at the time, and experiments were therefore continued there.

ESRK x
IS x

GLASGOW TESTS

The first tests were conducted entirely on music from Studio 1. The studio cubicle was equipped with an ESRK, with which balancing was being carried out.

The programmes included a mixed choir, the BBC Scottish Orchestra, and solo piano.

These tests covered both transmissions and rehearsals, and resulted in a slight preference in favour of the ESRK. The ISRK, while giving better definition on some solo instruments and voices, gave a somewhat hard quality on the ensemble. The Lansing loudspeaker gave some unpleasant effects at upper frequencies, of the type which have come to be known as "disembodied top" (i.e. the effect of the extreme high frequency register being detached from the rest of the reproduction) and was a little bass heavy.

Tests were next made with male speech in Studio 1. The speaking distance was greater than 18", and there was no microphone correction. In this case, the lower middle coloration introduced by the ESRK was very noticeable, and the ISRK gave definitely more natural reproduction. The Lansing loudspeaker gave the most realistic effect, but was again slightly bass heavy.

Except where the phenomena under investigation involve frequencies below 100 c/s, a speech test from a large studio is a very reliable guide to quality, since there is very little to go wrong. Provided that a proper distance from the microphone is maintained, there is no heavy coloration due to the studio itself, nor is there any question of wrong internal balance as in the case of an orchestra. It seemed reasonable to conclude, therefore, from the last test, that in spite of the slight preference so far felt for the ESRK, the ISRK was, in fact, the better reproducer. It was then decided to alter the studio conditions in order to determine (1) whether a better overall result could be obtained on the ISRK by special balancing, and (2) whether such special balancing would give acceptable results on other loudspeakers, particularly those of the wide range type such as the Lansing. This rebalancing was left to the S.P.E., who eventually arrived at a microphone position both higher and more distant than the original. The reproduction then obtained on the ISRK was a definite improvement on that previously obtained on the ESRK by balancing on the latter, the improvement being chiefly in string tone and general perspective. The same balance also gave good reproduction on the Lansing loudspeaker, there being in particular no "disembodied top". On the other hand, the quality from the ESRK on the new balance was very poor, with the lower middle coloration more obtrusive than before. It was found that a slight additional improvement could be made to the reproduction on the Lansing loudspeaker by adopting an even more distant microphone position, but the effect was then less good on the ISRK, and even

worse than before on the ESRK.

In the course of the speech tests mentioned above, an attempt had been made to improve on the performance of the ESRK by introducing electrical correction into the circuit, in the form of a general slope up towards the high frequency end. A slope of about 2 db per octave had been found to give some improvement, but the lower middle coloration was still noticeable on speech. The ESRK with this correction was tried on music with the new balance, but the reproduction was still much inferior to that obtainable on the ISRK without correction. It has already been noted in connection with the People's Palace experiments that electrical correction was capable upon occasion of reducing the difference between the reproductions of the ISRK and ESRK. In this case, however, studio conditions were so bad that the difference between the two loudspeakers was much less apparent than under the good conditions at Glasgow.

The conclusions thus reached may therefore be summed up as follows:

1. If balancing is carried out on the loudspeaker under test in each case the ISRK gives reproduction definitely superior to that obtainable with the ESRK.
2. Attempts to balance on the ESRK produced a result which was objectionable on a particular wide-range loudspeaker. These objectionable effects were, however, typical of what has already been experienced with other types of wide-range loudspeaker, and the conclusions are thought to be generally applicable. If, on the other hand, balancing was carried out on an ISRK, the result was acceptable on the wide-range loudspeaker. It appears, therefore, that the use of the ISRK in studio listening rooms would assist in making our programme material suitable for wide-range reproduction, although it is not suggested that the ISRK is completely interchangeable with the Lansing or any other wide-range loudspeaker for balancing purposes.

A few tests were also carried out on the Scottish Variety Orchestra in Studio 2. Here, although it was not possible to make such extensive changes in balance as was done in Studio 1, some definite results were noted. These may be summed up as follows:

- (a) With a balance which had been carried out on a flared cone B.T.H. loudspeaker, and a close multi-microphone technique, the ESRK gave a slightly better reproduction than the ISRK, while the quality from the Lansing loudspeaker was unpleasantly "edgy"
- (b) With a more distant single microphone, the reproduction from the flared cone B.T.H. loudspeaker in the studio cubicle was

confused and "muddy", while that from the ISRK was quite acceptable and that from the Lansing loudspeaker good.

It will be seen that these results support the conclusion already reached that the ISRK should be used for balancing whenever possible, and that when this is done, a relatively distant microphone position gives the best all-round result.

Most of the listening for the Glasgow tests was done in a large panelled room having two to three times the floor area of an average studio listening room. In some of the later tests, however, the listening was done in Studio 1 listening room, and although the quality was slightly inferior in this room to that in the large room previously referred to, the general conclusions were unaffected.

VARIATIONS BETWEEN SIMILAR LOUDSPEAKERS

In order that the results of the investigation should not be influenced by the peculiarities of any one loudspeaker unit, three ESRK loudspeakers and three ISRK loudspeakers were used in the course of the early tests, and all but one of these were tried in the Glasgow tests. The differences in response between the individual specimens of one type were not sufficient to affect the conclusions reached.

VARIATIONS IN ORCHESTRAL QUALITY IN STUDIO

It was noticed, both in the case of the BBC Scottish Orchestra and of the Scottish Variety Orchestra, that the standard of playing, particularly of the strings, was lower during rehearsal than on transmission, giving in the former case a confused or scratchy effect which could actually be heard in the studio, but which could, in the absence of a direct comparison, have been attributed to the reproducing system. This is an important point, as rehearsals have been commonly used in the past for test purposes, and it is felt that no transmission system should in future be condemned solely on the strength of a listening test on rehearsal.

CONCLUSIONS

The conclusions so far reached may be summarised as follows:

- (1) The earlier model of the corrugated cone B.T.H. loudspeaker with internal centring spider is the best at present in use in the Corporation.

- (2) With appropriate microphone technique and a good studio, very good reproduction can be obtained on a wide-range reproducing system, without the objectionable high-frequency effects often associated with such systems.
- (3) When balancing is carried out on the internal spider RK loudspeaker, the result is acceptable on a wide-range loudspeaker. On the other hand, a balance arrived at by listening on an external spider RK or flared cone B.T.H. loudspeaker may give unpleasant reproduction on a wide-range loudspeaker.
- (4) It is therefore recommended that the internal spider RK be used in future wherever possible in preference to the other two types mentioned, especially for balancing.
- (5) Some improvement in the response of the external spider RK loudspeaker may be obtained by electrical correction, but with good programme material the result is still inferior to that obtainable from the internal spider RK.

We wish to acknowledge the great assistance given by Messrs. Haworth and Macey of the staff of S.E.(S) in the course of the Glasgow experiments.

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ADDENDUM.

Since this report was written, the possibility of converting existing ESRK loudspeakers to take IS cones has been investigated.

The dies originally used in the production of these cones were destroyed by enemy action during the War. Fresh dies have been constructed by B.T.H. and cones can now be supplied. One of the specimens used in the Glasgow tests described in the report (see P.7) was from the new dies and others, supplied since, have been found to give similar reproduction; so that it can be said that the cones now obtainable will meet our requirements.

The mechanical details of conversion present little difficulty and the whole operation could probably be carried out by staff on stations. The procedure is (i) remove the old ES cone, cover the magnetic gap with three strips of adhesive tape arranged in a triangle leaving the centre of the pole exposed. (ii) mark the centre of the pole, drill and tap O.B.A. (iii) carefully remove all filings from the outside of the magnet and from the tapped hole. (iv) remove the protecting tape and fit new IS cone, using O.B.A. bolt, washers and spacing piece which can be obtained, if required, from B.T.H. It is not necessary to dismantle the magnet assembly itself, indeed to do so in the case of the permanent magnet model would result in demagnetisation.