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TECHNICAL SERVICES DIVISION

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REPORT No. 5.

TITLE: Frequency Tolerance necessary for Synchronized Operation of Radio Broadcasting Transmitters.

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Report on tests carried out by W. E. Baker for the Director Technical Services to determine whether "synchronised" operation of radio broadcasting transmitters (i.e. common channel common programme operation) can be effectively carried out with low frequency tolerances between transmitters.

(R. B. Mair.)

Director of Technical Services.

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General.

A suggestion has been made that some saving of equipment costs for synchronised operation may be effected by operating with a carrier frequency difference of about 15 c/s. It was decided to make a brief investigation of the proposal with equipment placed at the disposal of the Board by the P.M.G. Research Laboratories. There follows a theoretical generalisation of the problem which was confirmed experimentally in the laboratory tests.

Theory.

At frequency differences of about 15 c/s., the following effects cause reception to be poorer than with the closely synchronised case.

(a) The envelope formed by the addition of the two carriers has a fundamental 15 c/s. component with a second harmonic (30 c/s.) which is about 25 db. below 100 % modulation of the stronger carrier for a two to one ratio of carrier amplitudes. This unwanted component is within the audible range. With appreciably smaller carrier difference frequencies, the inaudibility of the ear, and receiver A.V.C. tend to make this effect negligible.

(b) The time constants of the A.V.C. circuits of normal medium wave receivers are such that A.V.C. does not smooth out variations of the carrier envelope at a frequency of 15 c/s., but causes the A.V.C. to operate at the average carrier level, which is greater than the level of the stronger carrier because of the downward peaked nature of the envelope, around the instants of destructive interference between the two carriers. This means that in many practical cases some parts of the beat frequency (15 c/s) envelope will be operating in the square law region of the second detector, and other parts in the linear region of the detector. The programme modulation output in the former case will be distorted and considerably lower in level than in the latter case, and with low carrier ratios the effective output will have minima in the output wave centred around the instants of destructive interference, thereby giving a characteristic warble in the receiver output. With low beat frequencies near synchronism this effect will be absent if the amplitude characteristic of the receiver A.V.C. system is good enough to smooth out variations of the modulation envelope at the beat frequency. This effect is present even when there are no distortions due to phase differences of the modulations of the two carriers (due to path differences, etc.)

With older type receivers which do not incorporate A.V.C., the results will be substantially the same with a 15 c/s. beat frequency, but with a near synchronous beat frequency, the wanted output modulation will be appreciably lower at instants of destructive interference if the detector stage linear, but if it drops into the square law region the output at these instants will be considerably lower as well as having increased distortion.

(c) When there are phase differences of the wanted modulation envelopes at the receiving point, due to path differences and/or delay lines in the transmitter modulating circuits, and this relative delay time exceeds a figure of about 50 micro-seconds, distortion is introduced in the receiver output at and near instants of destructive interference at the carrier frequencies. At these instants most of the respective modulation side bands of the two signals are phase additive, and consequently with small carrier amplitude ratios the resultant carrier can be over-modulated by the resultant side-bands, the phase relation between carrier and side bands is disturbed, and the beats between these exalted side bands are no longer negligible while the carrier is depressed. The result can be very objectionable distortion. If these instants of appreciable distortion occur frequently as they do with a beat frequency of 15 c/s., the result is more disturbing than when the beat rate is very small, particularly if, at the same time the characteristics of the A.V.C. system cause the signal to take an excursion into the square law region of detection.

Experimental Investigation.

The above theoretical generalisations were borne out in the laboratory tests. Two standard signal generators were modulated with a programme, a [illegible]0 micro-second delay being interposed in the modulation line to one signal generator. The stronger carrier input signal to the receiver was 100 microvolts, the two signal generators being paralleled at their output terminals.

It was found that when the carriers were synchronised as closely as practicable, the distortion and change of level at the instants of destructive interference were just barely tolerable with a carrier ratio of two to one, but were satisfactory with a carrier ratio of four to one. As the beat frequency was allowed to increase slowly, the carrier ratio had to be progressively increased for satisfactory reception, and with a 15 c/s. beat note, the minimum tolerable carrier ratio was 10 to 1. Removing the delay line from the modulation feed to the delayed signal generator improved the quality of reception in all cases as would be expected.

In a further test one of the signal generators was dispensed with and the national broadcast from Sydenham was picked up and applied , along with the other signal generator, to the receiver, and the tests repeated for various degrees of synchronizatio It was found that the results were substantially the same as those employing two signal generators and a delay line. This result was also as expected.

Conclusions.

The F.C.C. determinations in regard to synchronized broadcasting have been substantially verified, and could be used as a basis for Australian Engineering practice.

References.

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