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V.H.F. Field Strength Measurements over Medium Length Land Paths

By

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Summary: Field strength measurements were made over several overland transmission paths on Bands I and II, at distances up to 274 km. The measurements when corrected for transmitting aerial height above mean terrain and also for receiving site variation factor give field-strength/distance curves which are in reasonable agreement with the current C.C.I.R. tropospheric propagation curves. The range of fading and field strength exceeded in each month for specified time-percentages are also discussed.

1. Introduction

During 1959 the European Broadcasting Union submitted a document to the C.C.I.R. Study Group V in the form of a draft study programme which pointed out the desirability of obtaining statistical information on the fading characteristics of v.h.f. and u.h.f. signals within the distance range 0–200 km. The importance of this information arose from the fact that with the planning of v.h.f. and u.h.f. transmitter networks minimum distance separations between transmissions on adjacent or image channels might be relatively small, whereas the separation distances of co-channel stations could be readily assessed by means of the then existing (and subsequently revised) C.C.I.R. tropospheric propagation curves. The C.C.I.R. Los Angeles Plenary Assembly accepted the draft study programme, which was then formulated as Study Programme No. 140 and subsequently revised as part of the current Study Programme No. 189 of the Geneva Assembly in 1963.

This paper describes measurements made by the B.B.C. during 1961 and 1962 which were submitted to the C.C.I.R. as a contribution to the Study Programmes. Although the data are primarily for v.h.f. broadcast planning the radio wave propagation information is of interest in assessing the performance of the Instrument Landing System for aircraft.[1] It is decided, therefore, to give a wider circulation to the detailed measurements.

Field strength records were made of a selection of B.B.C. transmissions over paths ranging in length from 62 to 274 kilometres. Two receiving sites were used, one at the B.B.C. Monitoring Station, Caversham Park, Oxfordshire, and the other at an unattended radio station at Mursley, Buckinghamshire. Four Band I television sound and four Band II f.m. sound broadcasting transmissions were measured at each of the receiving sites, giving in all propagation data for sixteen transmission paths. The measurements were carried out over the period from June 1961 to December 1962. Further measurements were made during the latter half of 1963 for the purpose of obtaining corrections for normalizing the long-term measured field strengths to be representative for 50% of locations.

2. Sites, Equipment and Analysis

2.1. *Sites*

Figure 1 shows the geographical distribution of the transmitting and receiving sites. Further details of the sites are also given in Tables 1 and 2.

2.2. *Equipment*

The main features of the receivers are their reliability and gain stability when used over a long period of time. The Band I receiver intermediate frequency is 270 kHz and the selectivity response is substantially constant over ± 5 kHz, falling by 45 dB at ± 20 kHz. This narrow pass-band rejects the sound carriers of other co-channel transmitters offset by 20 kHz. The Band II receiver intermediate frequency is 2·2 MHz and the selectivity response is reasonably constant over a range of ± 40 kHz, falling by 6 dB at ± 75 kHz and 50 dB at ± 200 kHz. The receivers for both bands have a logarithmic input/output characteristic over a range of 50 dB, but the overall gain of the receivers may be adjusted to suit the median signal for a particular path by means of attenuators inserted between the signal- and intermediate-frequency units.

At the receiving sites, the output of each receiver was connected to a voltage coder[2] which was common to the eight receivers. The coder sampled the signal of each receiver sequentially and, depending upon the field strength value, converted it to one of thirty-one levels of a five-unit binary code. The signal level was then recorded on punched paper tape. The time

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Table 1
Transmitting site details

Location	Frequency MHz	Site height a.m.s.l. m	Aerial height a.g.l. m	Aerial polarization	Latitude	Longitude
Crystal Palace	41·5	110	130	V	51°25′20″N	00°04′17″W
North Hessary Tor	48·23	509	193	V	50°32′59″N	04°00′26″W
North Hessary Tor	88·1	509	164	H	50°32′59″N	04°00′26″W
Peterborough	63·27	56	127	H	53°30′26″N	00°20′30″W
Peterborough	90·1	56	99	H	53°30′26″N	00°20′30″W
Rowridge	88·5	137	90	H	50°40′34″N	01°22′02″W
Sutton Coldfield	58·25	169	224	V	52°35′59″N	01°49′57″W
Sutton Coldfield	88·3	169	197	H	52°35′59″N	01°49′57″W
Wenvoe	63·25	128	224	V	51°27′32″N	03°16′48″W
Wenvoe	89·95	128	197	H	51°27′32″N	03°16′48″W
Wrotham	89·1	219	124	H	51°19′11″N	00°17′20″E

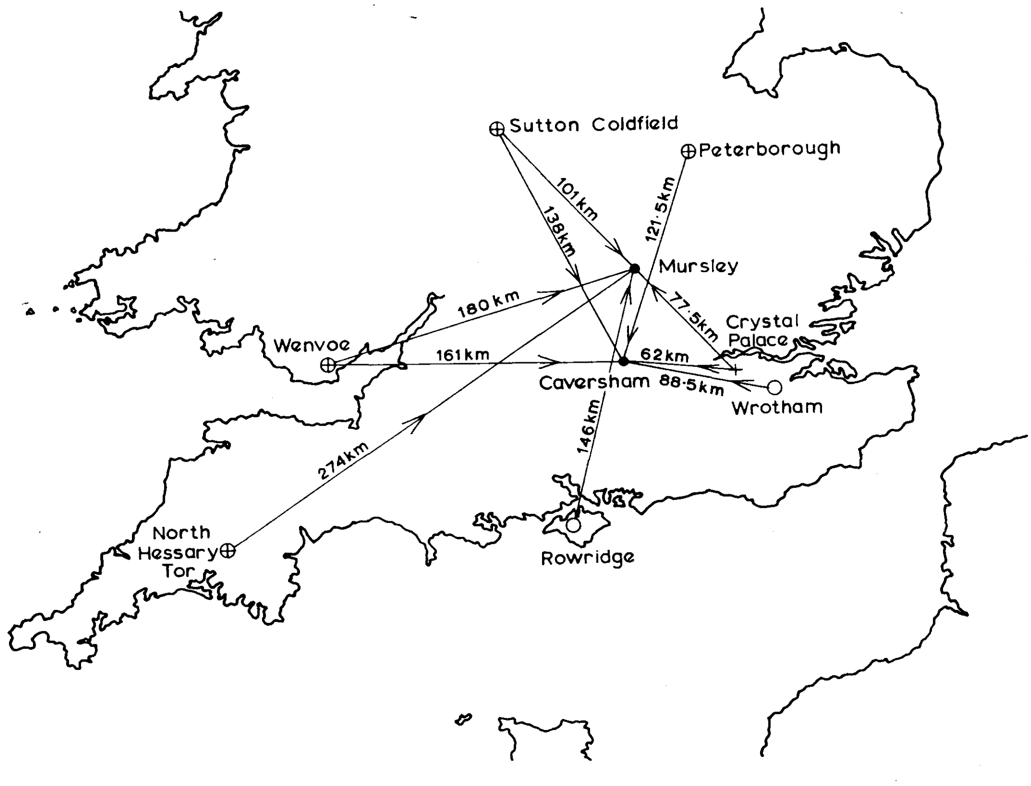


Fig. 1. Geographical distribution of transmitting and receiving sites.

● Receiving sites — + Transmitting site (Band I)
○ Transmitting site (Band II) — ⊕ Transmitting sites (Bands I and II)

Table 2
Receiving site details

Receiver location	Transmitter location	Path distance km	Receiving site: Site height a.m.s.l. m	Approximate aerial height a.g.l. m	True bearing to transmitter	Latitude	Longitude
Caversham	Crystal Palace	62·0	82·3	11·0	95°	51°28′52″N	00°57′23″W
,,	Peterborough	121·5	,,	,,	19°	,,	,,
,,	Sutton Coldfield	138·0	,,	,,	334°	,,	,,
,,	Wenvoe	161·0	,,	,,	270°	,,	,,
,,	Wrotham	88·5	,,	,,	101°	,,	,,
Mursley	Crystal Palace	77·5	158	9·1	140°	51°57′12″N	00°48′05″W
,,	North Hessary Tor	274·0	,,	,,	236°	,,	,,
,,	Rowridge	146·0	,,	,,	195°	,,	,,
,,	Sutton Coldfield	101·0	,,	,,	317°	,,	,,
,,	Wenvoe	180·0	,,	,,	253°	,,	,,

required for a complete cycle for sampling the output of the eight receivers was four minutes and the signal from each receiver was thus sampled fifteen times per hour.

Pen recorders were also connected to the outputs of the receivers to provide signal records that could be visually examined for the presence of interference and for occasional checking of the accuracy of the punched paper tape data. The recording charts were run at a speed of 2 inches (5·1 cm) per hour.

Conventional commercial-type Bands I and II dipoles or 'H' aerials were used at the receiving sites. At Caversham they were mounted on the top of a building at a height of approximately 36 ft (11 m) above ground level (a.g.l.). Similar aerials were used at Mursley, mounted on tubular masts at a height of about 30 ft (9·1 m) a.g.l.

2.3. *Analysis*

The punched tape at each receiving site was renewed at the end of every month and the used tape returned to base for analysis. Originally, the tape containing the field strength data was fed into a thirty-one level analyser which counted the number of times each level of field strength was recorded. The field strength exceeded for certain fixed time-percentages was then manually calculated from the cumulative distribution of the sampled data. During the series of measurements, however, the B.B.C. acquired a computer and the work of analysing the punched tape was subsequently transferred to the computer.

The records of the measurements were analysed to determine the length of time during which the signal levels exceeded various values of field strength. These time durations, expressed as percentages of the overall valid recording time, were then plotted against field strength normalized for an effective radiated power (e.r.p.) of 1 kW. Separate graphs were prepared for each transmission path.

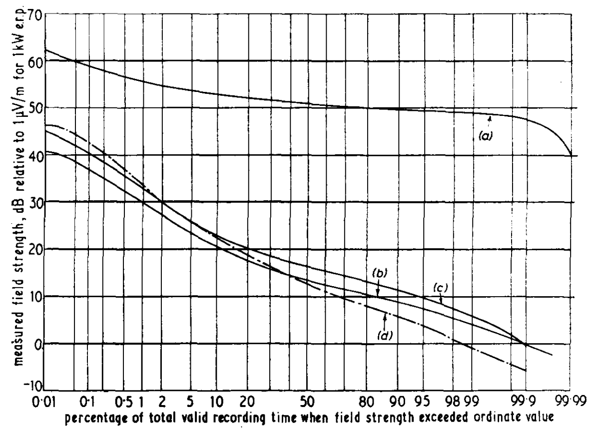
3. Results

3.1. *Variation of Field Strength with Time*

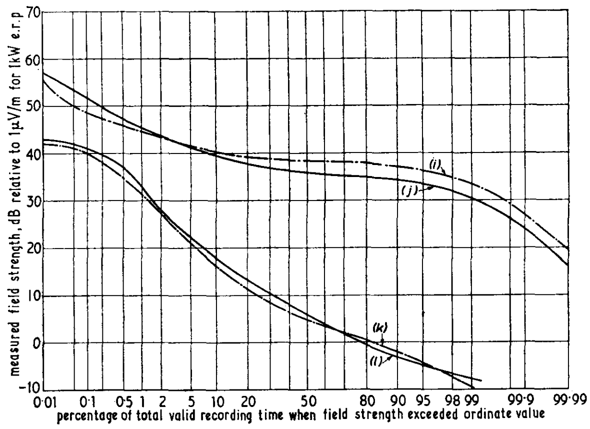
The results of the Caversham and Mursley Bands I and II measurements are plotted in Fig. 2 as field strength exceeded against percentage of the total valid recording time. The curves for each receiving site and frequency band are shown separately and are accompanied by a table giving the total number of hours relating to each curve and the free-space field strength for the different paths. The field strengths for selected time-percentages derived from Fig. 2 are listed in Table 3.

An inspection of Fig. 2 shows that, in general, the slope of the curves increases with distance. The figures also reveal that the curves converge at the low time-percentage values. This implies that for the high amplitude signals, that is, during abnormal conditions, the signal values are less dependent upon distance.

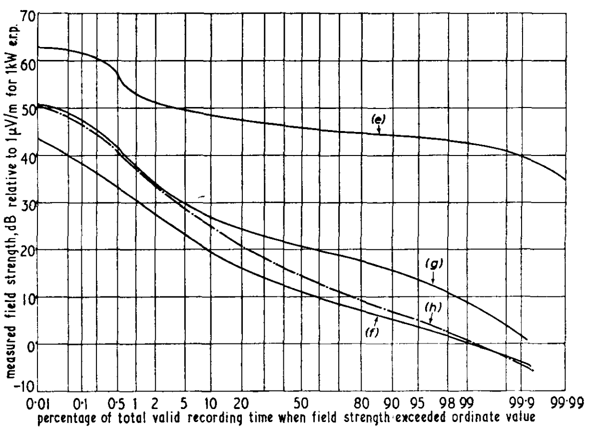
Curves (a), (e), (i), (j) and (m) in these figures relate to the shorter paths where, during normal propagation conditions, the signal is virtually con-



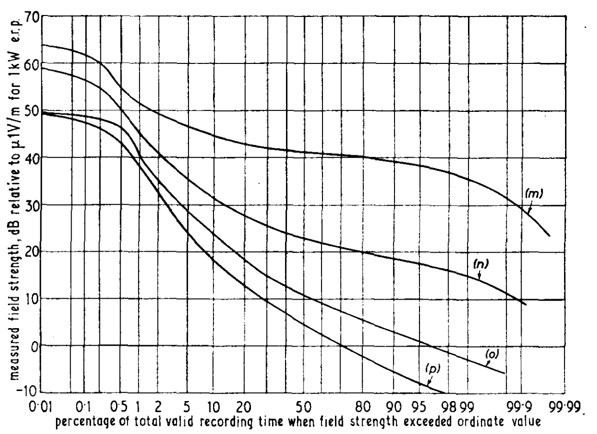
Curve	Transmitting site	Receiving site	Frequency MHz	Distance km	Total hours recorded	Free space field dB (µV/m) for 1 kW e.r.p.
(a)	Crystal Palace	Caversham	41·5	62·0	7072	71·0
(b)	Peterborough	Caversham	63·27	121·5	6898	65·2
(c)	Sutton Coldfield	Caversham	58·25	138·0	7137	64·1
(d)	Wenvoe	Caversham	63·25	161·0	6923	62·7



Curve	Transmitting site	Receiving site	Frequency MHz	Distance km	Total hours recorded	Free space field dB (µV/m) for 1 kW e.r.p.
(i)	Crystal Palace	Mursley	41·5	77·5	5814	69·1
(j)	Sutton Coldfield	Mursley	58·25	101·0	5507	66·8
(k)	Wenvoe	Mursley	63·25	180·0	5508	61·8
(l)	North Hessary Tor	Mursley	48·23	274·0	5661	58·2



Curve	Transmitting site	Receiving site	Frequency MHz	Distance km	Total hours recorded	Free space field dB (µV/m) for 1 kW e.r.p.
(e)	Wrotham	Caversham	89·1	88·5	7106	68·0
(f)	Peterborough	Caversham	90·1	121·5	6287	65·2
(g)	Sutton Coldfield	Caversham	88·3	138·0	7115	64·1
(h)	Wenvoe	Caversham	89·95	161·0	6982	62·7



Curve	Transmitting site	Receiving site	Frequency MHz	Distance km	Total hours recorded	Free space field dB (µV/m) for 1 kW e.r.p.
(m)	Sutton Coldfield	Mursley	88·3	101·0	5912	66·8
(n)	Rowridge	Mursley	88·5	146·0	5870	63·5
(o)	Wenvoe	Mursley	89·95	180·0	5503	61·8
(p)	North Hessary Tor	Mursley	88·1	274·0	5705	58·2

Fig. 2. Variation of field strength with time.

Table 3

Measured field strengths at Caversham and Mursley

Curves in Fig. 2	Transmitting site	Receiving site	Frequency MHz	Distance km	Field strength, dB (μV/m) for 1 kW e.r.p., exceeded for stated percentage of the time						
					0·1%	1%	10%	50%	90%	99%	99·9%
(a)	Crystal Palace	Caversham	41·5	62·0	59·0	55·5	53·0	51·0	49·5	49·0	47·5
(b)	Peterborough	,,	63·27	121·5	37·0	30·0	20·5	13·5	9·0	4·0	0
(c)	Sutton Coldfield	,,	58·25	138·0	40·5	33·0	23·0	16·5	11·5	6·0	−0·5
(d)	Wenvoe	,,	63·25	161·0	42·5	33·5	22·5	13·0	6·0	−1·0	−5·5*
(e)	Wrotham	,,	89·1	88·5	61·5	53·0	48·5	45·5	44·0	42·5	39·5
(f)	Peterborough	,,	90·1	121·5	38·5	30·5	19·5	11·0	5·0	0	−4·0
(g)	Sutton Coldfield	,,	88·3	138·0	47·5	37·5	27·0	20·5	15·5	9·0	1·5
(h)	Wenvoe	,,	89·95	161·0	46·5	37·0	25·0	14·5	7·0	0·5	−4·5
(i)	Crystal Palace	Mursley	41·5	77·5	48·5	44·5	40·0	38·5	37·0	33·5	27·0
(j)	Sutton Coldfield	,,	58·25	101·0	51·5	45·5	39·5	36·0	34·5	30·5	24·0
(k)	Wenvoe	,,	63·25	180·0	40·0	31·5	16·5	5·0	−2·0	−9·0*	N.L.
(l)	North Hessary Tor	,,	48·23	274·0	41·0	33·0	18·0	6·0	−3·0	−7·5	N.L.
(m)	Sutton Coldfield	,,	88·3	101·0	61·5	51·5	44·5	41·0	39·0	35·5	29·5
(n)	Rowridge	,,	88·5	146·0	56·5	45·0	31·5	23·0	18·5	15·0	N.L.
(o)	Wenvoe	,,	89·95	180·0	48·5	40·0	23·5	10·5	3·0	−3·0	N.L.
(p)	North Hessary Tor	,,	88·1	274·0	47·5	38·0	18·0	4·5	−5·5	−12·0*	N.L.

* Extrapolated value. N.L. Noise level.

stant. During abnormal propagation conditions, however, these signals fade slowly about the median. The signals received over the longer transmission paths are subject to varying degrees of slow and fast fading when propagation conditions are normal. High level signals of virtually constant amplitude are, however, also received at the greater distances when abnormal propagation conditions prevail.

3.2. *Range of Fading between Various Time-percentages*

The range of fading is defined as the signal strength exceeded for given percentages of time, expressed as a ratio of the median value. The ranges are given in Table 4 and plotted against distance in Fig. 3(a) and (b) for Bands I and II respectively. With fading ratios expressed in decibels a linear relationship gave a reasonable approximation to the measurements provided distance is plotted to a logarithmic rather than to a linear scale. This relationship must therefore be taken to give the 'best-fit'.

Two aspects of the fading displayed by the curves are of interest. The high field-strength values that occur for less than 10% of the time are important, because in planning broadcast services it is usual to protect a transmission from co-channel interference for at least 90% of the time. From the point of view of reception, and in particular reception for use as a rebroadcast service, it is important to know the incidence of 'fade-outs', that is the ratio of the median to the value occurring for 90% of the time, or for at least 99% of the time.

Figures 3(a) and (b) show that both in Bands I and II the range of fading increases with distance.

It will be noted that the slope of the 50%–1% line is in each case greater than the 50%–99% line, and that the slope of the 50%–10% line is similarly greater than that of the 50%–90% line, indicating that the long-term variation of field strength (expressed in decibels) about the median signal value is asymmetrical; the range of fading relative to the median is greater for the low time-percentages than for the high time-percentage values.

Figure 3(c) reproduces, for comparison purposes, the Bands I and II best-fit lines shown in Figs. 3(a) and (b). It will be seen that at the greater distances Band II signals vary over a wider range than Band I, and although differences exist between the signal characteristics in Bands I and II they are not very great. The combined Bands I and II best-fit lines for the various fading ranges were therefore calculated and appear in Fig. 3(d).

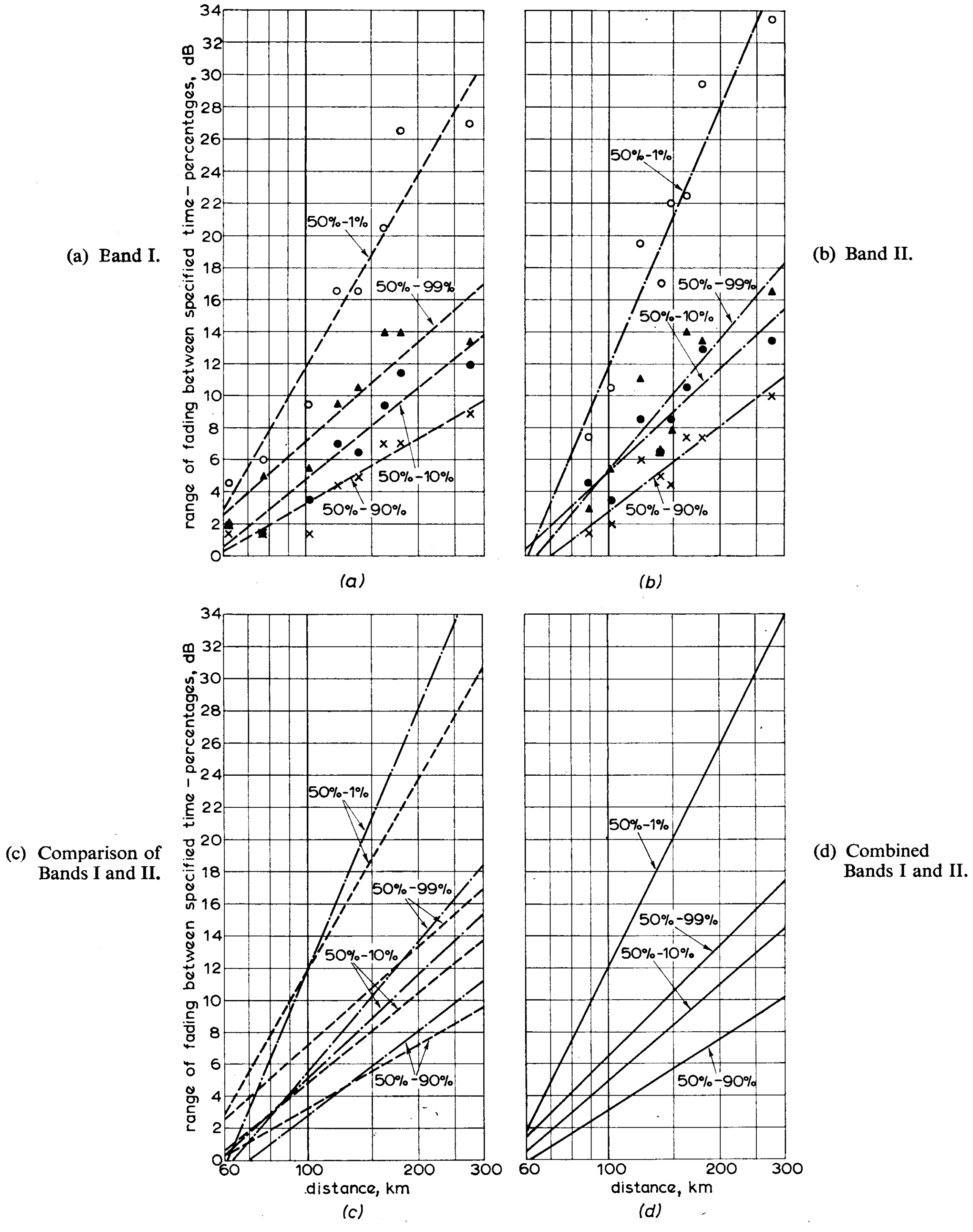


Fig. 3. Range of fading between various time-percentages.

○ 50%–1% ● 50%–10% × 50%–90% ▲ 50%–99%

——— Band I —·—·— Band II ——— Bands I and II

Table 4
Fading range between time-percentages

Curves in Fig. 2	Transmitting site	Receiving site	Frequency MHz	Distance km	Range of fading between various time-percentages 50%–1%	50%–10%	50%–90%	50%–99%
(a)	Crystal Palace	Caversham	41·5	62·0	4·5	2·0	1·5	2·0
(b)	Peterborough	,,	63·27	121·5	16·5	7·0	4·5	9·5
(c)	Sutton Coldfield	,,	58·25	138·0	16·5	6·5	5·0	10·5
(d)	Wenvoe	,,	63·25	161·0	20·5	9·5	7·0	14·0
(e)	Wrotham	,,	89·1	88·5	7·5	4·5	1·5	3·0
(f)	Peterborough	,,	90·1	121·5	19·5	8·5	6·0	11·0
(g)	Sutton Coldfield	,,	88·3	138·0	17·0	6·5	5·0	6·5
(h)	Wenvoe	,,	89·95	161·0	22·5	10·5	7·5	14·0
(i)	Crystal Palace	Mursley	41·5	77·5	6·0	1·5	1·5	5·0
(j)	Sutton Coldfield	,,	58·25	101·0	9·5	3·5	1·5	5·5
(k)	Wenvoe	,,	63·25	180·0	26·5	11·5	7·0	14·0
(l)	North Hessary Tor	,,	48·23	274·0	27·0	12·0	9·0	13·5
(m)	Sutton Coldfield	,,	88·3	101·0	10·5	3·5	2·0	5·5
(n)	Rowridge	,,	88·5	146·0	22·0	8·5	4·5	8·0
(o)	Wenvoe	,,	89·95	180·0	29·5	13·0	7·5	13·5
(p)	North Hessary Tor	,,	88·1	274·0	33·5	13·5	10·0	16·5

3.3. *Variation of Monthly Field Strengths for Selected Time-percentages*

The field strengths exceeded in each month for selected time-percentages are plotted in order of distance in Figs. 4 and 5. The 99·9 time-percentages could not be given for some of the longer transmission paths as the corresponding field strengths were below the noise level of the receivers.

The standard deviations of these monthly field strengths were calculated for the different transmission paths and selected time-percentages. Using the standard deviation values, the combined Bands I and II standard deviation best-fit lines for each time-percentage are given in Fig. 6. The standard deviation lines show that the month-to-month field strength variations increase with distance for all time-percentages. In general, the gradient of the line decreases with an increase in time-percentage.

An inspection of Figs. 4 and 5 shows that the 0·1% and 1% monthly field strength values are enhanced, particularly for September and October 1961 and December 1962. These high signals invariably occur during days when the weather is anticyclonic. Such weather may cause an inverse of temperature or lapse of humidity with height in the lower atmosphere and subsiding air then spreads out above a cold and moist layer of air. At the boundary between the dry and moist air a greater-than-normal negative refractive-index gradient occurs, causing increased refraction, reflection or partial reflection of the radio waves. In general, during these abnormal propagation conditions higher-than-average field strengths are received.

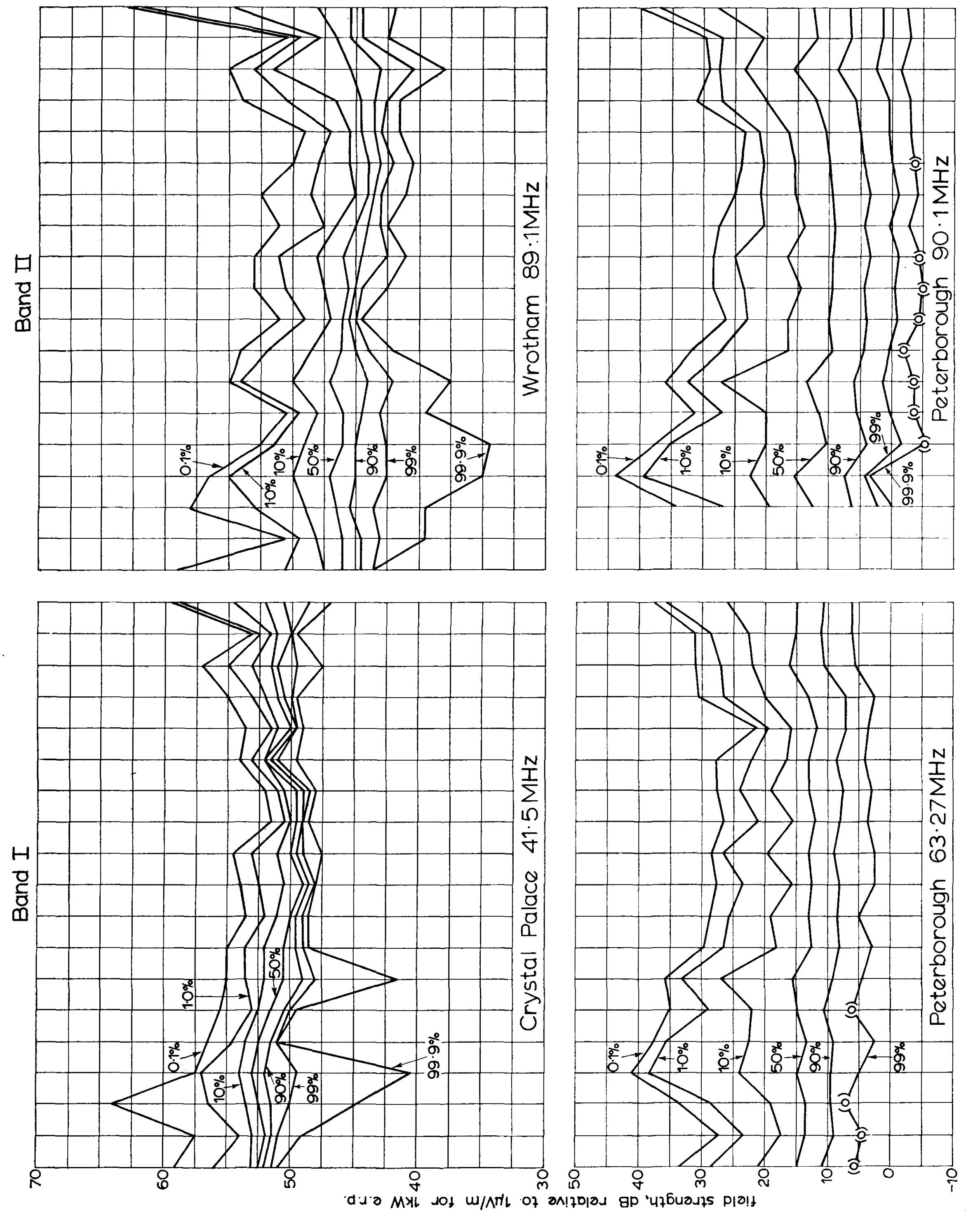
The received signal for the shorter paths is virtually constant during normal (cyclonic weather) propagation conditions. However, during abnormal propagation conditions the signal fades slowly about the median and although the signals are generally enhanced there are occasions when drop-outs occur. This phenomenon is clearly shown in Fig. 5 for the December 1961, Crystal Palace, 99·9% field strength value. These drop-outs are probably caused by two-ray paths giving at times a signal cancellation.

It would be unwise to draw any firm conclusion from Figs. 4 and 5 concerning seasonal variations in propagation as the measurements only cover a period of 16–19 months.

3.4. *Variation of Field Strength with Distance*

3.4.1. Site variation factor

In order to determine whether the two receiving sites chosen for the experiment were representative of the areas in which they were situated, field strength


Band I
Band II
Crystal Palace 41·5 MHz
Wrotham 89·1 MHz
Peterborough 63·27 MHz
Peterborough 90·1 MHz
0·1%
1·0%
10%
50%
90%
99%
99·9%
field strength, dB relative to 1μV/m for 1kW e.r.p.

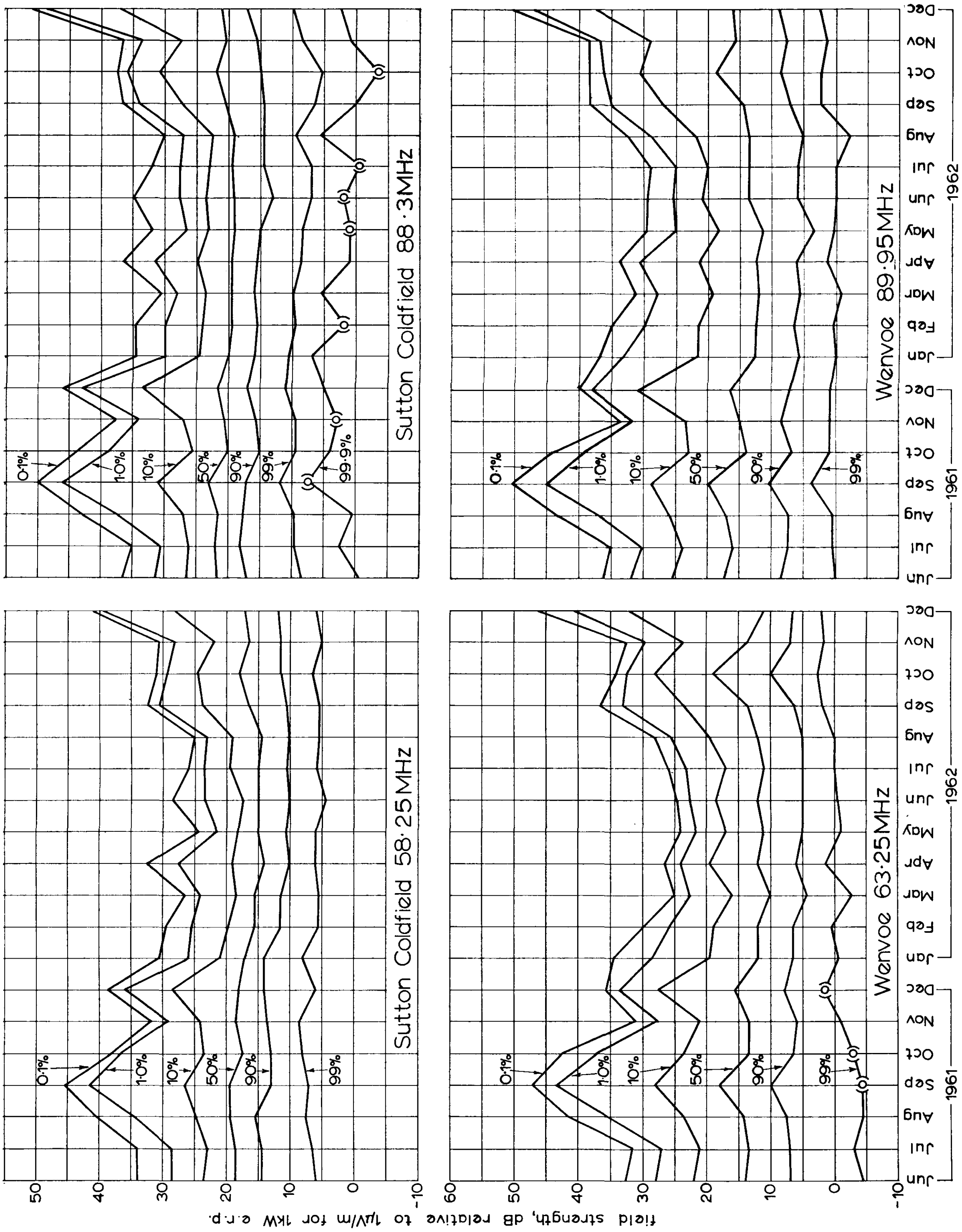
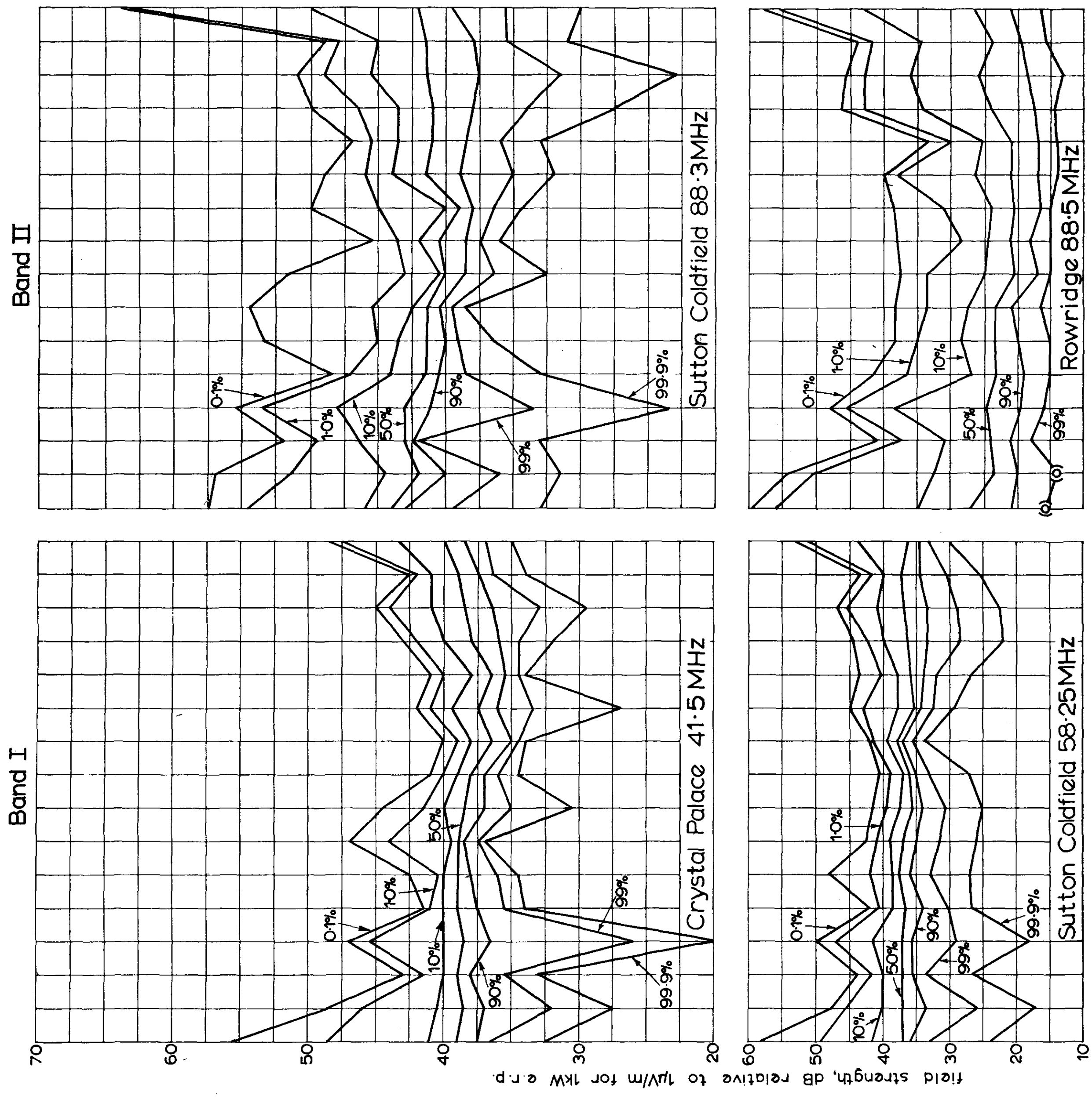


Fig. 4. Field strengths exceeded in each month for selected time-percentages (Caversham). (○) Extrapolated
Crystal Palace 62·0 km; Wrotham 88·5 km; Peterborough 121·5 km; Sutton Coldfield 138·0 km; Wenvoe 161·0 km.


Band I
Band II
Crystal Palace 41·5 MHz
Sutton Coldfield 58·25 MHz
Sutton Coldfield 88·3 MHz
Rowridge 88·5 MHz
field strength, dB relative to 1µV/m for 1kW e.r.p.
0·1%
1·0%
10%
50%
90%
99%
99·9%

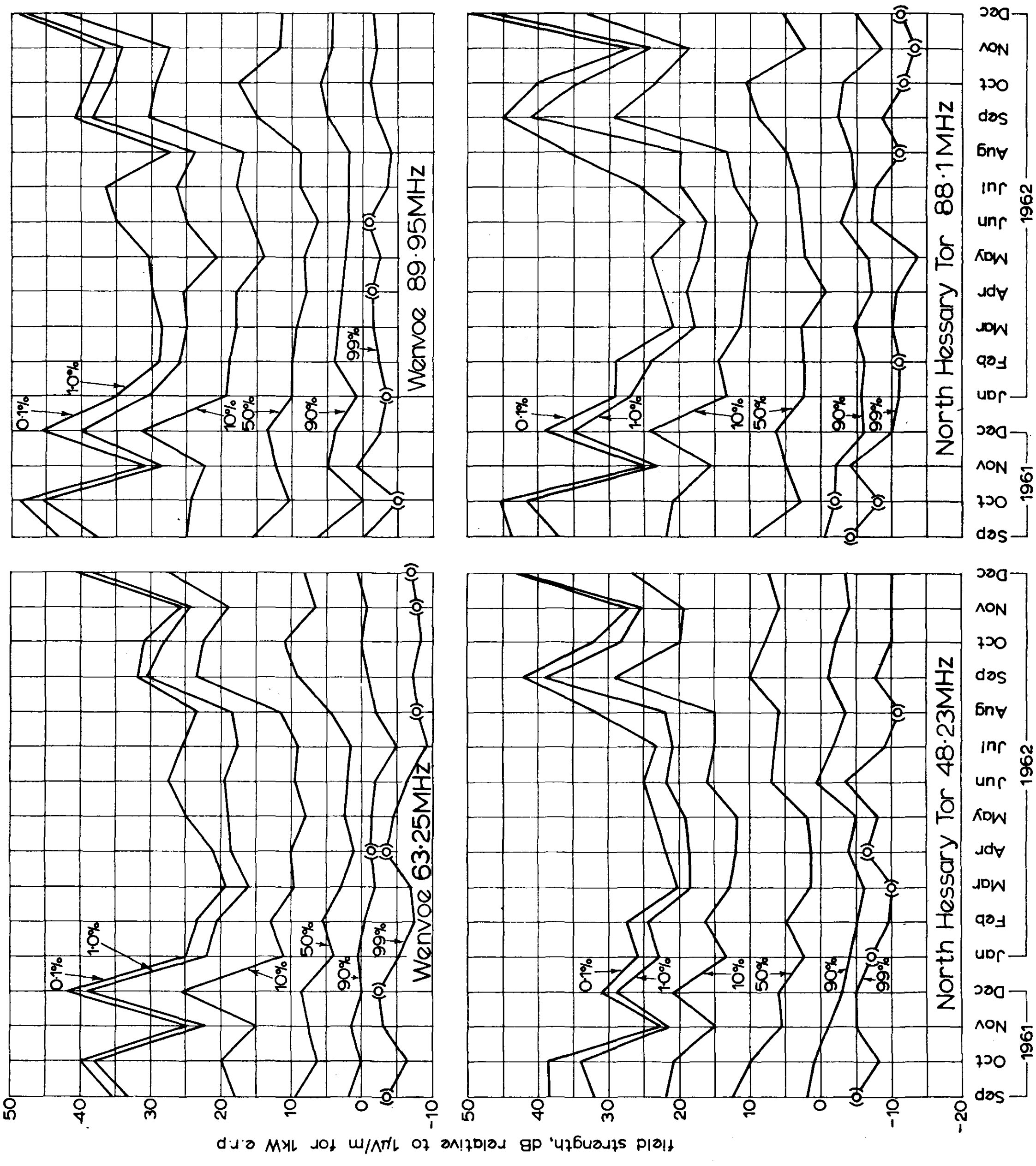


Fig. 5. Field strengths exceeded in each month for selected time percentages (Mursley). (○) Extrapolated
Crystal Palace 77·5 km; Sutton Coldfield 101·0 km; Rowridge 146·0 km; Wenvoe 180·0 km; North Hessary Tor 274·0 km.

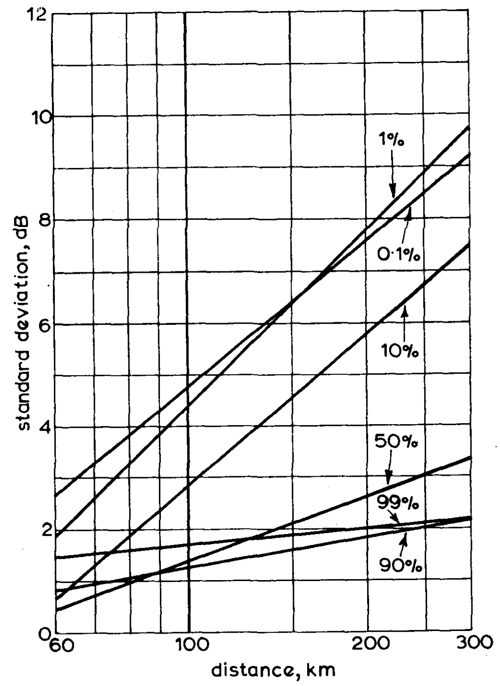


Fig. 6. Bands I and II—Standard deviation of field strengths exceeded in each month for selected time-percentages.

Table 5

Site variation factors

Transmitting site	Receiving site	Frequency MHz	Site variation factor dB
Crystal Palace	Caversham	41·5	−12·0
Peterborough	,,	63·27	+3·5
Sutton Coldfield	,,	58·25	− 5·0
Wenvoe	,,	63·25	−15·0
Wrotham	,,	89·1	− 4·5
Peterborough	,,	90·1	− 2·5
Sutton Coldfield	,,	88·3	− 8·0
Wenvoe	,,	89·95	−10·5
Crystal Palace	Mursley	41·5	− 7·5
Sutton Coldfield	,,	58·25	− 5·0
Wenvoe	,,	63·25	+ 4·0
North Hessary Tor	,,	48·23	− 6·0
Sutton Coldfield	,,	88·3	−10·0
Rowridge	,,	88·5	−10·5
Wenvoe	,,	89·95	− 0·5
North Hessary Tor	,,	88·1	− 5·0

Table 6

Corrections for a transmitting aerial height above mean terrain of 300 metres

Transmitting site	Receiving site	Frequency MHz	Distance km	Aerial height above mean terrain m	Corrections to normalize the measured field strengths for an aerial height of 300 metres above mean terrain dB 1%	10%	50%
Crystal Palace	Caversham	41·5	62·0	160	+4·5	+6·0	+7·0
Peterborough	,,	63·27	121·5	183	+1·5	+2·0	+3·0
Sutton Coldfield	,,	58·25	138·0	325	−0·5	−0·5	−0·5
Wenvoe	,,	63·25	161·0	234	+1·0	+1·0	+1·0
Wrotham	,,	89·1	88·5	250	+1·0	+1·0	+1·5
Peterborough	,,	90·1	121·5	155	+2·5	+4·0	+4·0
Sutton Coldfield	,,	88·3	138·0	298	0	0	0
Wenvoe	,,	89·95	161·0	207	+1·0	+1·5	+2·5
Crystal Palace	Mursley	41·5	77·5	150	+3·5	+5·5	+6·0
Sutton Coldfield	,,	58·25	101·0	315	−0·5	−0·5	−0·5
Wenvoe	,,	63·25	180·0	235	+0·5	+0·5	+0·5
North Hessary Tor	,,	48·23	274·0	583	−3·0	−3·5	−4·0
Sutton Coldfield	,,	88·3	101·0	287	+0·5	+0·5	0
Rowridge	,,	88·5	146·0	99	+3·5	+5·5	+5·5
Wenvoe	,,	89·95	180·0	208	+1·5	+2·0	+1·5
North Hessary Tor	,,	88·1	274·0	554	−2·0	−3·5	−3·5

measurements were made at various locations in their vicinity. Measurements of approximately 30 minutes duration were carried out at temporary sites within a radius of 8 km from each permanent site. The ratio of the median field strength at the temporary sites to that for the same period at the permanent site was calculated. The average of these ratios is known as the site variation factor (s.v.f.), and was measured for each transmission frequency and each of the two permanent receiving sites. The appropriate s.v.f. was then used as a correction to the measured field strengths to give the fields that would have been measured at 50% of locations in the vicinity of each permanent site.

The results of the Caversham and Mursley s.v.f. measurements are listed in Table 5. These show that with the exceptions of the Band I Peterborough–Caversham and Wenvoe–Mursley transmission paths, the s.v.f.s have negative values, indicating that the Caversham and Mursley sites receive higher fields than the average in their area. Table 5 also reveals that at each receiving site the s.v.f.s vary according to the direction of reception, as would be expected. In addition, for the same transmission path, the s.v.f.s vary with the frequency. The transmission paths involved in this comparison are not identical, as the Bands I and II transmitting aerials are mounted at different heights on the mast and separate receiving aerials are used.

3.4.2. Transmitting aerial height above mean terrain

Because there were differences between the heights of the different transmitting sites above the surrounding terrain and the heights of the different transmitting aerials above ground level, it seemed desirable to apply, beside the s.v.f. correction, a correction for the differences in the transmitting aerial heights. This was done for comparison with the C.C.I.R. Recommendation 370 (Geneva 1963), in which field-strength/distance curves relating to overland paths are used in the planning of broadcast services. Separate curves are drawn for different transmitter aerial heights above mean terrain for the v.h.f. and u.h.f. frequency bands, mean terrain being somewhat arbitrarily defined as the height of the aerial above the average level of the ground between the distances of 3 km and 15 km from the transmitter.

Table 6 lists the aerial height above mean terrain for each transmission path and also shows the correction derived from the curves in Recommendation 370, which normalizes the field strength for other transmitting heights to a height of 300 m. Recommendation 370 gives the field-strength/distance curves for the 1, 10 and 50 time-percentages and thus corrections for these time-percentages only are given in Table 6. The 1% corrections have been used for time-percentages less than 1% and similarly the 50% corrections used for time-percentages greater than 50%. Though not strictly applicable, they help to reduce the differences in field strength due to differences in transmitting aerial height for time-percentage curves for which no values are available in Recommendation 370. These corrections have been applied to the measured field strengths listed in Table 3 and give, together with the s.v.f.s, the corrected values in Table 7.

3.4.3. Field-strength/distance curves

The field strengths (corrected for transmitting aerial height and s.v.f.) listed in Table 7 are used to derive, by the method of least squares, the field-strength/distance curves for selected time-percentages; the results are shown in Fig. 7. The relationship between field-strength plotted in decibels and distance plotted to a logarithmic scale are drawn as straight lines, for the reason given in Section 3.2. This implies that the field E varies with distance d,

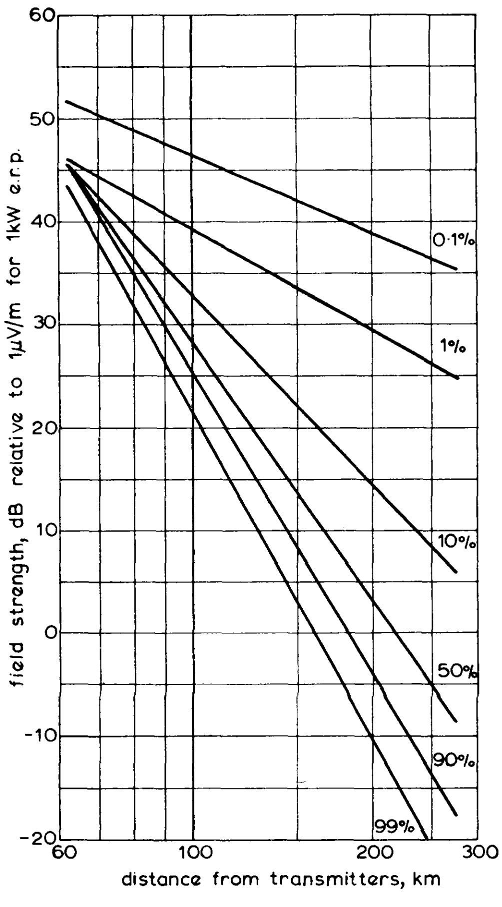


Fig. 7. Variation of Bands I and II field strengths as a function of distance. The curves show the field strength exceeded for different time-percentages.

Table 7

Field strength corrected for s.v.f. and transmitter aerial height above mean terrain of 300 metres

Transmitting site	Receiving site	Frequency MHz	Distance km	Field strength, dB (μV/m) for 1 kW e.r.p. (corrected for s.v.f. and mean terrain) exceeded for stated percentage of the time 0·1%	1%	10%	50%	90%	99%	99·9%
Crystal Palace	Caversham	41·5	62·0	51·5	48·0	47·0	46·0	44·5	44·0	42·5
Peterborough	,,	63·27	121·5	42·0	35·0	26·0	20·0	15·5	10·5	6·5
Sutton Coldfield	,,	58·25	138·0	35·0	27·5	17·5	11·0	6·0	0·5	−6·0
Wenvoe	,,	63·25	161·0	28·5	19·5	8·5	−1·0	−8·0	−15·0	−19·5
Wrotham	,,	89·1	88·5	58·0	49·5	45·0	42·5	41·0	39·5	36·5
Peterborough	,,	90·1	121·5	38·5	30·5	21·0	12·5	6·5	1·5	−2·5
Sutton Coldfield	,,	88·3	138·0	39·5	29·5	19·0	12·5	7·5	1·0	−6·5
Wenvoe	,,	89·95	161·0	37·0	27·5	16·0	6·5	−1·0	−7·5	−12·5
Crystal Palace	Mursley	41·5	77·5	44·5	40·5	38·0	37·0	35·5	32·0	25·5
Sutton Coldfield	,,	58·25	101·0	46·0	40·0	34·0	30·5	29·0	25·0	18·5
Wenvoe	,,	63·25	180·0	44·5	36·0	21·0	9·5	2·5	−4·5	—
North Hessary Tor	,,	48·23	274·0	32·0	24·0	8·5	−4·0	−13·0	−17·5	—
Sutton Coldfield	,,	88·3	101·0	52·0	42·0	35·0	31·0	29·0	25·5	19·5
Rowridge	,,	88·5	146·0	49·5	38·0	26·5	18·0	13·5	10·0	—
Wenvoe	,,	89·95	180·0	49·5	41·0	25·0	11·5	4·0	−2·0	—
North Hessary Tor	,,	88·1	274·0	40·5	31·0	9·5	−4·0	−14·0	−20·5	—

according to the law $E = kd^m$, where k is a parameter related to the transmission path and m is the slope of the best fit line. The values of m and $20 \log k$ are given in Table 8.

The field-strength/distance curves in Fig. 7 show that the slope of the curves increases with the increasing time-percentage and indicates a reduced dependence of field strength on distance for small time-percentages.

The 1, 10 and 50 time-percentage curves from Fig. 7 are re-drawn in Fig. 8, together with the appropriate C.C.I.R. field-strength/distance curves.[3] The B.B.C. Bands I and II measurements cover the frequency range 41·5 to 90·1 MHz, whereas the Bands I to III C.C.I.R. curves are for the frequency range 40 to 250 MHz. The B.B.C., however, have previously carried out Band III overland measurements utilizing a frequency of 180·4 MHz and these field-strength/distance curves are also shown in Fig. 8. The Band III measurements, which lasted for a period of almost 3½ years, are corrected for s.v.f. and aerial height of approximately 300 m above mean terrain.

An inspection of Fig. 8 reveals that there is good agreement between the B.B.C. Bands I and II curves and the earlier Band III curves. In general, the Band III curves are higher than the Bands I and II curves, but only by a few decibels.

Table 8

Field strength/distance parameters

Time-percentage	m	$20 \log k$
0·1	−1·252	96·3
1	−1·608	103·4
10	−3·047	154·6
50	−4·165	194·7
90	−4·916	221·7
99	−5·312	233·8

The B.B.C. 1% curves indicate a higher received field than the C.C.I.R. 1% curve, the difference increasing to about 8 dB at 274 km. The B.B.C. and C.C.I.R. 10% curves are in good agreement. The same applies for the 50% curves up to about 200 km. Beyond 200 km the B.B.C. 50% curves indicate a lower field than the C.C.I.R. 50% curve by approximately 2·5 to 5 dB, at least up to 274 km.

4. Conclusions

The range of fading between the 50 and 1, 50 and 10, 50 and 90, and 50 and 99 time-percentage field strengths increases with distance. The range of fading

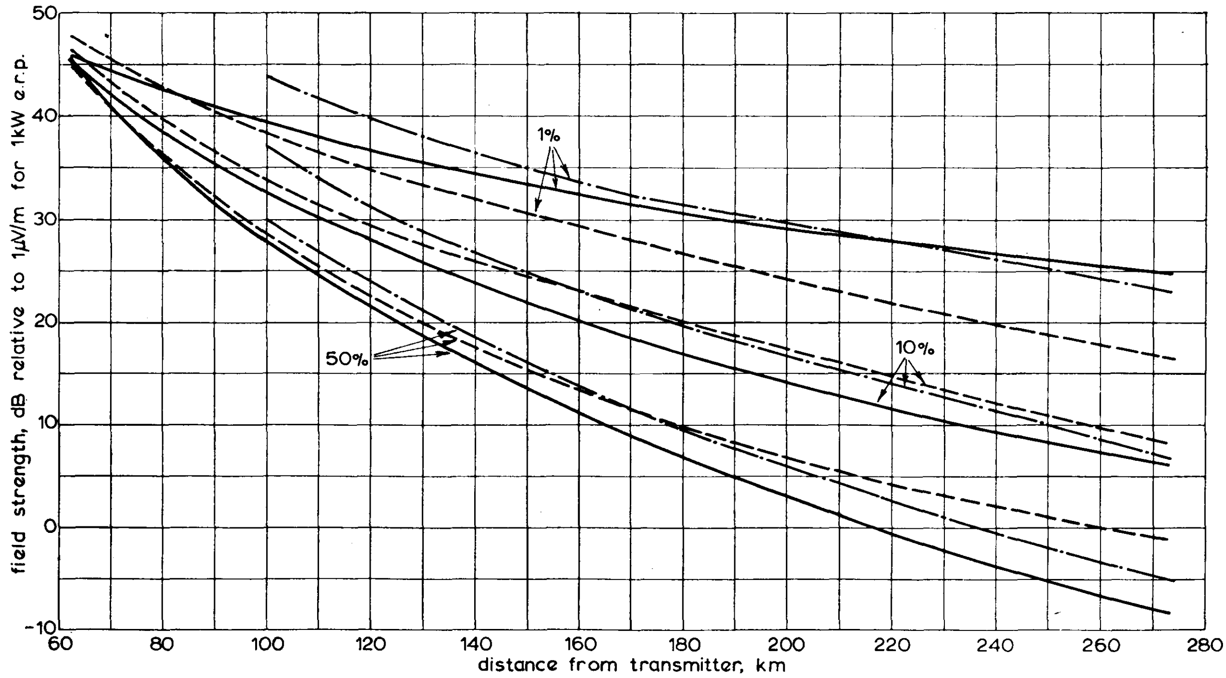


Fig. 8. Comparison of B.B.C. and C.C.I.R. field-strength/distance curves.

——— Bands I and II (B.B.C.) —·—·— Band III (B.B.C.) — — — Bands I to III (C.C.I.R.)

relative to the median field strength is greater for the low time-percentage field strengths as compared with the high time-percentage values.

The variation of monthly field strengths for the selected time-percentages increases with distance; this is, however, less pronounced for the higher time-percentage values.

The B.B.C. Bands I and II and the Band III field-strength/distance curves are similar. The 10% and 50% B.B.C. curves are in reasonable agreement with the equivalent C.C.I.R. curves, but the B.B.C. 1% curves indicate higher fields than the C.C.I.R. 1% curve by about 8 dB at 274 km.

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