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A COMPARISON OF THE ELECTRICAL CONDITIONS OF THE ATMOSPHERE AT KEW AND ESKDALEMUIR,

WITH

NOTES ON OBSERVATIONS OF ATMOSPHERIC ELECTRICITY MADE IN OTHER COUNTRIES.

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A COMPARISON OF THE ELECTRICAL CONDITIONS OF THE ATMOSPHERE AT KEW AND ESKDALEMUIR, WITH NOTES ON OBSERVATIONS OF ATMOSPHERIC ELECTRICITY, MADE IN OTHER COUNTRIES.

THE electrical conditions discussed in the following pages are (1) the electric potential gradient in the air near the ground; (2) the number of small ions of both signs; and (3) their respective mobilities; (4) the electric conductivity of the air; and (5) the vertical electric current passing from the air to the earth. At both observatories that we are considering there are instruments for continuously recording only the first of these conditions, viz., the potential gradient. The other properties of the air are measured by eye observations, taken on as many days as possible. The potential gradient will be first discussed, and afterwards the other electrical properties of the air, about which we have less information.

ELECTRIC POTENTIAL GRADIENT.

The Recording Apparatus.—The method of continuously recording the potential gradient is the same as that employed at most observatories. An insulated tube projects from the wall of the building and is brought to the potential of the air near its end by a 'collector.' At both Kew and Eskdalemuir a 'water-dropper' is used as collector. The potential of this insulated tube is recorded photographically by an electrometer. It is assumed that the potential shown by this electrograph is proportional to the potential gradient in the open, away from the disturbing effect of building, etc., and a factor is obtained for converting the reading of the electrograph into the potential gradient, in volts per metre, in the open. This is done by measuring the potential of the air at a known height above level, open ground, and comparing this with the potential shown by the electrograph at the same time.

Selection of days to be used.—The electric potential gradient in the air is a very variable element, and, especially during rain, the gradient may undergo large and rapid fluctuations both in magnitude and sign, while at such times the trace not infrequently goes off the sheet, the gradient being too high to be measured with the apparatus. The question, therefore, arises in working up the results, as to how these cases should be dealt with, since they cannot be regarded as normal conditions. It has been the practice in the past, at Kew, to select the curves for ten days in each month, in which there were no negative or unmeasurable portions, and these alone were considered. At Kew it is generally possible to obtain ten such quiet days in each month, but at Eskdalemuir the electric conditions are much more disturbed, and it would be quite impossible to do so for many of the winter months.

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TABLE I.—ELECTRIC POTENTIAL GRADIENT AT ESKDALEMUIR. 1911–1912. In Volts per Metre.

On 0, a Days.

Month.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	24h.	Means.	No. of Days.
1911.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	
January	324	304	265	273	254	253	228	247	283	298	297	294	288	302	273	278	381	447	445	468	450	404	388	328	324	324	10
Feb.	279	251	259	232	231	223	238	205	213	216	248	317	297	290	237	214	232	295	325	401	421	433	379	305	279	281	8
March	234	196	165	163	168	180	174	176	164	223	182	173	195	203	197	209	216	261	251	280	307	286	257	271	234	214	9
April	236	194	199	141	142	144	137	146	151	148	149	173	171	188	190	211	235	224	253	272	291	265	219	189	236	195	5
May	232	233	246	249	242	214	256	237	215	175	157	156	154	167	166	172	172	176	192	219	239	267	256	258	232	210	15
June	185	185	183	206	227	220	195	162	137	124	144	138	123	123	129	134	143	149	152	165	171	197	193	181	185	165	13
July	186	167	162	145	142	140	142	155	135	128	118	127	127	112	123	133	135	147	145	181	201	223	212	177	186	157	10
August	239	240	192	174	203	232	241	212	192	168	133	138	145	144	161	161	166	176	171	190	218	232	221	203	239	190	10
Sept.	252	214	187	167	150	144	153	212	214	170	154	158	153	156	185	195	234	235	235	260	319	281	303	301	252	210	7
October	306	282	277	269	286	310	329	331	309	251	209	211	204	204	220	215	240	294	345	362	352	387	359	346	306	287	8
Nov.	200	164	150	159	158	231	292	237	274	361	358	342	316	297	275	244	343	365	371	403	317	279	257	219	200	275	4
Dec.	391	236	306	288	366	346	292	315	331	406	513	384	301	222	169	204	221	265	240	177	234	282	251	356	391	295	2
1912.																											
January	332	281	224	231	239	226	211	295	361	358	340	314	328	324	315	349	310	353	492	418	422	358	396	341	332	326	5
Feb.	333	278	274	281	272	259	254	397	444	481	461	437	265	234	247	293	237	273	309	402	368	290	247	261	333	317	3
March	291	281	168	160	123	193	101	145	162	142	181	160	172	163	149	170	164	187	280	333	327	295	286	295	291	205	2
April	248	235	221	210	192	191	223	234	208	182	159	146	139	143	150	146	141	149	163	195	241	267	287	280	248	198	14
1911.																											
Winter	299	239	245	238	252	263	260	251	275	320	354	334	300	278	238	235	294	343	345	362	380	349	319	302	299	294	24
Equinox	282	222	207	185	186	194	198	216	210	198	174	179	181	188	198	208	231	253	271	293	317	305	284	277	282	227	29
Summer	210	206	196	193	204	202	208	192	170	149	138	140	137	136	145	150	154	162	165	189	207	230	220	205	210	179	48

TABLE II.—ELECTRIC POTENTIAL GRADIENT AT ESKDALEMUIR. 1911–12. In Volts per Metre.

From all complete "ordinary" days.

Month.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	24h.	Means.	No. of Days.
1911.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	
January	291	253	224	222	206	211	199	219	263	262	272	263	241	260	233	258	300	407	447	437	427	370	331	281	290	291	14
Feb.	282	246	258	235	234	238	239	218	223	248	277	321	314	299	272	265	304	354	374	414	458	443	380	291	282	300	11
March	201	169	146	145	150	153	142	148	140	188	157	156	179	191	193	191	190	232	228	258	284	254	228	233	201	190	14
April	196	190	187	151	139	141	138	155	165	149	141	159	167	175	185	199	212	200	209	223	221	187	161	164	196	176	9
May	214	210	213	218	209	190	225	214	196	162	156	157	151	161	156	159	168	169	188	216	237	264	244	242	214	197	19
June	175	176	174	192	205	206	191	162	141	124	140	133	118	122	132	137	138	147	155	173	180	203	186	180	175	162	17
July	176	174	178	144	153	160	167	161	153	152	140	138	137	124	126	136	140	155	158	183	194	217	214	194	176	161	19
August	224	206	179	192	212	228	237	211	187	158	133	135	140	147	161	158	156	168	160	185	196	230	200	203	224	164	14
Sept.	248	222	204	207	175	168	188	219	213	171	153	132	136	139	165	174	186	237	195	224	200	239	278	289	248	198	11
October	262	248	254	248	248	250	264	269	270	227	213	222	213	202	223	212	238	292	332	354	346	352	328	302	262	265	12
Nov.	170	173	138	140	123	159	203	199	239	301	261	286	271	284	238	248	306	306	316	355	300	272	254	238	170	241	8
Dec.	326	270	259	225	267	286	282	256	297	301	307	278	265	285	241	212	279	276	205	266	334	299	346	386	326	281	7
1912.																											
January	225	222	198	204	188	205	214	225	242	255	255	238	281	301	290	324	314	325	364	341	328	298	328	248	225	267	17
Feb.	283	237	220	176	209	182	146	233	263	286	298	312	247	248	250	263	283	305	323	339	331	326	344	354	283	269	9
March	179	215	171	165	133	172	109	154	184	158	142	138	150	130	92	115	164	178	189	199	217	201	167	172	179	162	6
April	202	192	183	171	159	158	178	189	183	161	158	143	131	138	145	143	138	146	123	166	203	222	237	231	202	171	20
1911.																											
Winter	267	235	220	205	207	223	231	223	255	278	279	287	273	282	246	246	297	336	335	368	380	346	328	299	267	278	40
Equinox	227	207	198	188	178	178	183	198	197	184	166	167	174	177	191	194	206	240	241	265	263	258	249	247	227	207	46
Summer	197	191	186	186	195	196	205	187	169	149	142	141	136	138	144	147	150	160	165	189	202	228	211	205	197	171	69

TABLE III.—ELECTRIC POTENTIAL GRADIENT AT ESKDALEMUIR. 1911–12. In Volts per Metre.

From every available reading.

Month.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	24h.	Means.
1911.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.
January	230	198	181	175	156	177	161	188	207	202	247	255	226	244	232	237	278	334	351	369	373	309	284	235	235	249
Feb.	208	189	190	185	174	171	175	150	159	174	218	242	262	239	211	210	249	277	325	345	343	380	295	251	198	234
March	191	170	158	154	145	151	120	126	114	162	135	146	156	171	180	183	178	201	204	231	267	250	219	203	189	176
April	124	95	127	83	29	118	31	29	95	106	85	123	129	129	131	164	159	162	179	169	205	169	177	162	132	124
May	219	212	200	205	202	164	190	200	171	153	152	163	134	157	152	96	157	167	185	217	235	260	239	228	212	186
June	141	167	162	151	163	171	168	108	100	111	119	78	69	112	80	104	74	77	74	147	160	176	160	164	133	126
July	180	175	174	136	149	154	164	155	141	139	123	132	125	111	131	137	149	165	164	176	190	210	209	200	180	158
August	204	183	203	211	223	227	221	209	196	162	136	138	136	146	144	132	97	147	154	174	178	217	212	183	191	176
Sept.	219	176	139	126	165	113	169	211	204	182	161	167	149	165	174	172	192	219	216	237	260	234	300	281	234	193
October	244	241	245	251	257	244	248	268	266	199	185	195	145	149	127	163	223	208	299	311	315	314	290	274	242	236
Nov.	140	151	165	125	117	125	147	170	170	142	157	172	217	185	202	217	197	229	237	317	211	200	157	227	139	182
Dec.	116	45	32	−26	73	215	166	147	250	208	213	257	230	183	252	295	314	301	292	194	159	158	152	175	120	183
1912.																										
January	197	190	181	142	113	100	148	92	163	186	199	208	222	247	251	260	273	278	286	259	229	191	232	213	198	203
Feb.	157	112	204	48	226	102	14	186	223	236	233	234	240	245	234	166	206	203	243	216	237	231	176	164	151	189
March	137	105	74	25	31	115	120	56	126	129	95	88	108	93	90	10	84	80	121	31	89	49	48	86	137	83
April	198	182	182	176	167	156	162	167	145	118	131	127	130	135	148	146	140	138	145	161	180	205	217	214	198	161
1911.																										
Winter	174	146	142	115	130	172	162	164	196	182	209	232	234	213	224	240	259	285	301	306	272	262	222	222	173	212
Equinox	194	170	167	153	149	156	142	158	170	162	142	158	145	154	153	170	188	198	224	237	262	242	246	230	199	182
Summer	186	184	185	176	184	179	186	168	152	141	132	128	116	132	127	117	119	139	144	178	191	216	205	194	179	162

TABLE IV.—ELECTRIC POTENTIAL GRADIENT AT KEW, 1911–1912. In Volts per Metre.

From ten selected "quiet" days per month.

Month.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	24h.	Means.
1911.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.	v/m.
January	390	371	350	307	278	322	353	417	479	527	524	518	526	523	502	506	505	513	537	523	522	518	507	450	390	457
Feb.	356	338	311	290	287	278	288	320	341	385	409	403	347	313	268	301	320	328	364	413	421	423	407	372	356	345
March	318	284	241	199	225	251	289	301	383	445	471	454	450	454	449	457	445	456	448	485	413	400	379	373	318	378
April	309	275	231	251	246	248	266	307	347	342	311	236	208	213	243	233	228	245	274	344	381	379	383	362	309	286
May	231	222	200	195	189	209	248	267	318	340	297	272	266	242	215	196	201	229	257	266	298	282	281	254	231	249
June	202	201	168	149	136	153	195	242	285	297	291	251	239	213	213	216	218	237	249	250	238	231	194	187	202	219
July	211	180	155	146	146	164	171	226	260	281	235	216	183	176	168	184	195	215	228	243	271	251	258	251	211	209
August	207	177	154	134	148	149	175	223	239	237	230	198	204	200	208	207	195	239	266	280	215	289	273	259	207	217
Sept.	241	229	212	205	187	208	224	253	305	317	306	262	238	222	221	224	221	239	261	298	311	289	268	258	241	250
October	300	270	244	243	271	285	305	356	426	423	427	429	425	438	435	440	428	447	423	423	390	384	379	338	300	372
Nov.	351	296	290	269	248	264	296	339	415	437	431	403	357	337	350	377	402	418	433	450	432	413	402	375	351	366
Dec.	219	189	191	191	181	195	209	256	323	358	341	325	285	266	255	287	304	317	322	329	311	284	262	254	219	269
1912.																										
January	461	427	416	393	363	389	435	491	608	654	624	552	548	545	560	586	560	580	580	584	588	568	539	510	461	523
Feb.	285	254	246	251	238	256	281	352	430	458	493	428	386	370	334	316	315	355	373	363	333	331	331	312	285	337
March	218	212	184	166	170	172	182	252	276	257	234	215	198	195	203	206	224	234	261	292	298	288	278	253	218	228
April	252	226	196	195	187	182	199	257	313	359	315	268	246	231	230	250	265	290	308	346	376	364	352	308	252	269
1911.																										
Winter	329	298	285	264	248	264	286	333	389	426	426	412	379	359	344	368	383	394	414	429	421	409	394	363	329	359
Equinox	292	265	232	225	232	249	272	305	366	382	379	346	331	332	337	339	331	347	352	388	374	364	353	333	292	322
Summer	213	195	170	157	155	169	198	240	276	289	264	234	224	208	202	201	203	230	250	260	281	264	252	238	213	224

The electric character of the day at Eskdalemuir is classified according to whether any negative gradient occurs, and also according to the number and size of the fluctuations of the potential. Thus, 2, 1, or 0 signifies that much, little, or no negative gradient occurred during the day; and a, b, or c denote that the potential was steady, occasionally fluctuating, or very oscillatory. Mr Walker has proposed to consider only the days of character '0, a'; *i.e.* those days with a steady, positive potential gradient throughout. Mean hourly values of the potential gradient for each month have, therefore, been calculated, taking account of the '0, a' days only. These give smooth curves for the daily variation in most months, but in some very disturbed months the number of '0, a' days is too small to give a daily variation of any value. (See December 1911 and March 1912).

When the curves were measured at Eskdalemuir, hourly means were calculated for each month, using every hour in which the potential gradient could be measured on the curves. In this case only parts of many days are represented in the mean, the unmeasurable hours having to be omitted. These means have been plotted, and in most cases they give smoother curves for the diurnal variation than might be expected; but this cannot be regarded as a satisfactory method of treating the data.

Dr Chree suggested that it might be better to omit those days in which any hours were missing, and to use only complete days. Another set of hourly means has therefore been calculated from what might be called the 'complete ordinary' days. In this case readings which were very abnormal have been rejected, the criterion being whether their inclusion would change the mean for that hour by more than ten per cent. Also only those days were employed in which each hour could be used. The number of such days is still often small, but it is nearly double the number of "0, a" days, and in disturbed months the results obtained in this way are certainly the most satisfactory.

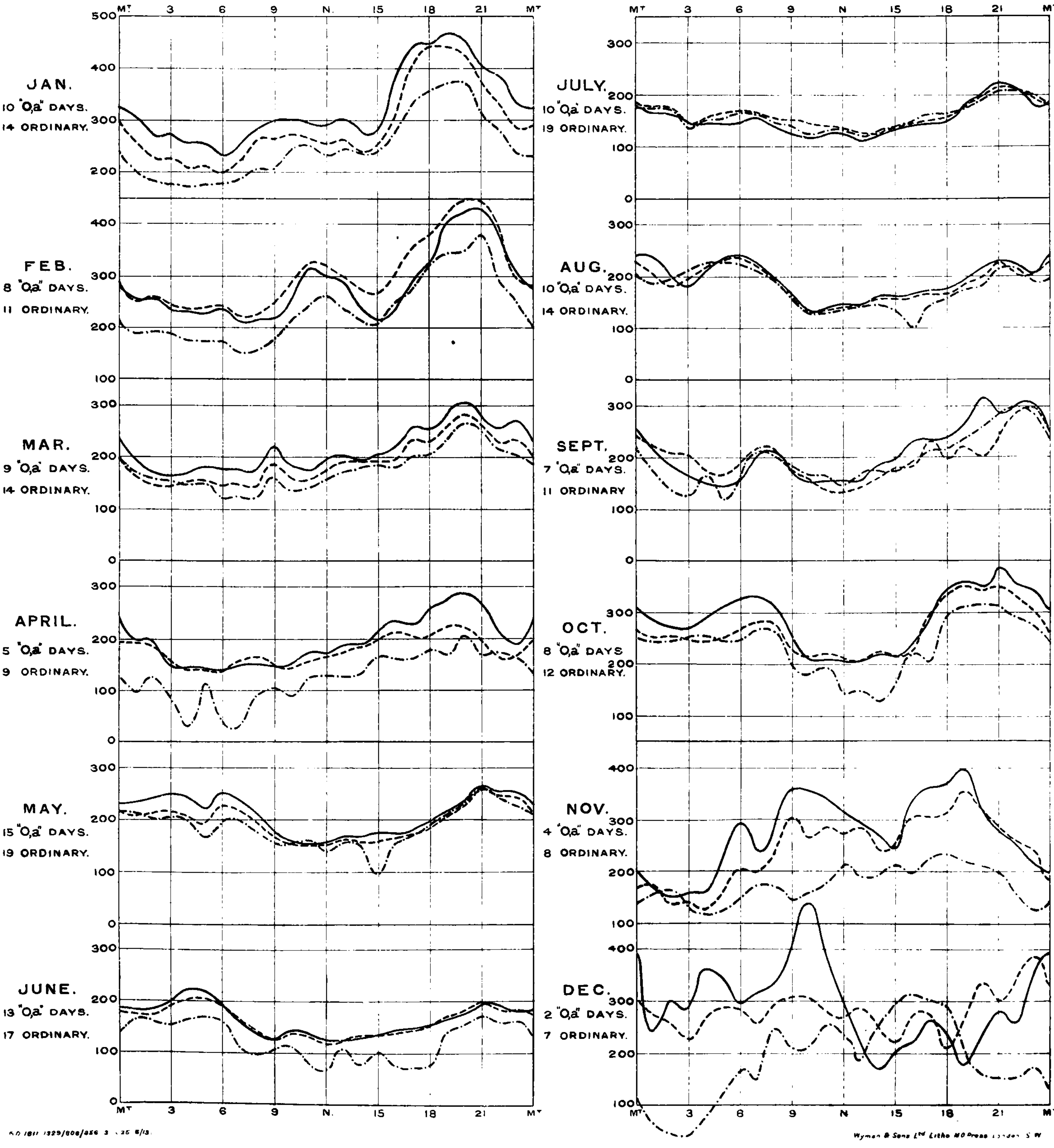
In many of the summer months the curves for the daily variations are very similar, whichever set of days be used. For the sake of comparison the diurnal variations for each month, from the three sets of days, are given in Tables I, II, and III, and are shown graphically in Plates 26, 27, 29. The winter of 1911–12 seems to have been a very disturbed period at Eskdalemuir, and the monthly curves are very erratic. The test to decide which of the three sets of days is the most satisfactory to use, seems to be to find which set gives the smoothest curves, and which gave curves most alike for the same month in two different years. In many cases the curves from the 'ordinary' days are very similar to those from the "0, a" days, but in some months they are decidedly better, while in no month are they worse. It was therefore decided to take the 'ordinary' days for comparison with the results at Kew. The very close agreement in many months between the curves for the daily variation, as obtained from the three sets of days, shows that these curves are very satisfactory. As was to be expected, the mean values obtained from the 'ordinary' days are generally rather lower than those obtained from the '0, a' days, while the means from every possible reading are still lower.

On Plate 31 are given the curves for the annual variation of potential gradient obtained from the three sets of days. The curve obtained from all possible readings is seen to be much less regular than those from either the '0, a' days, or 'ordinary' days. There seems very little to choose between these last two curves of the annual variation.

Comparison of the Potential Gradient at Kew and Eskdalemuir.—Unfortunately the observations of the potential gradient at Eskdalemuir are only available for the

Diurnal Variation of Potential Gradient in volts per metre at Eskdalemuir, 1911.

———— "O,a" DAYS.
- - - - - - ALL COMPLETE ORDINARY DAYS
—·—·—·— EVERY POSSIBLE READING.



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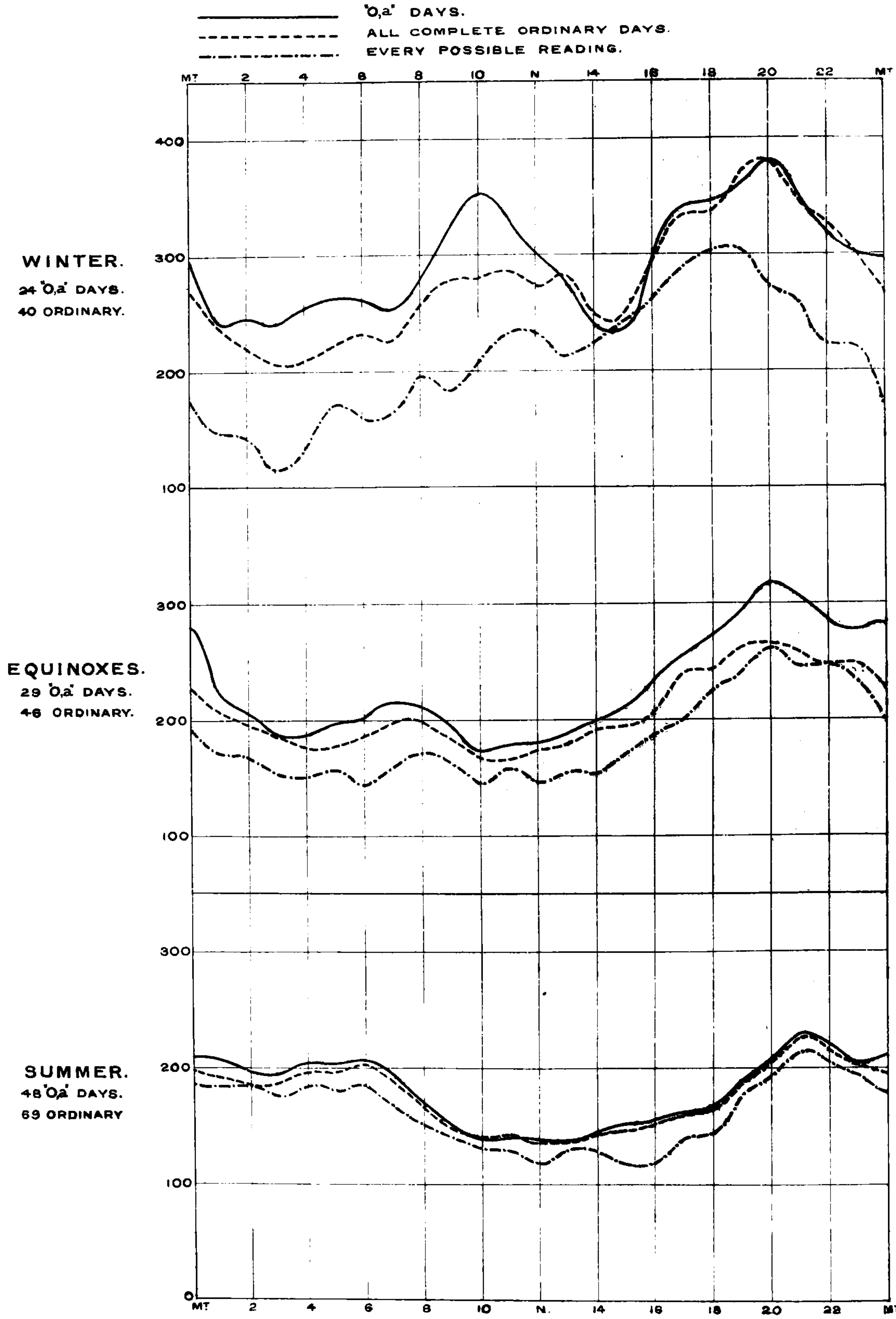
Diurnal Variation of Potential Gradient in Volts per Metre at Eskdalemuir, 1911.



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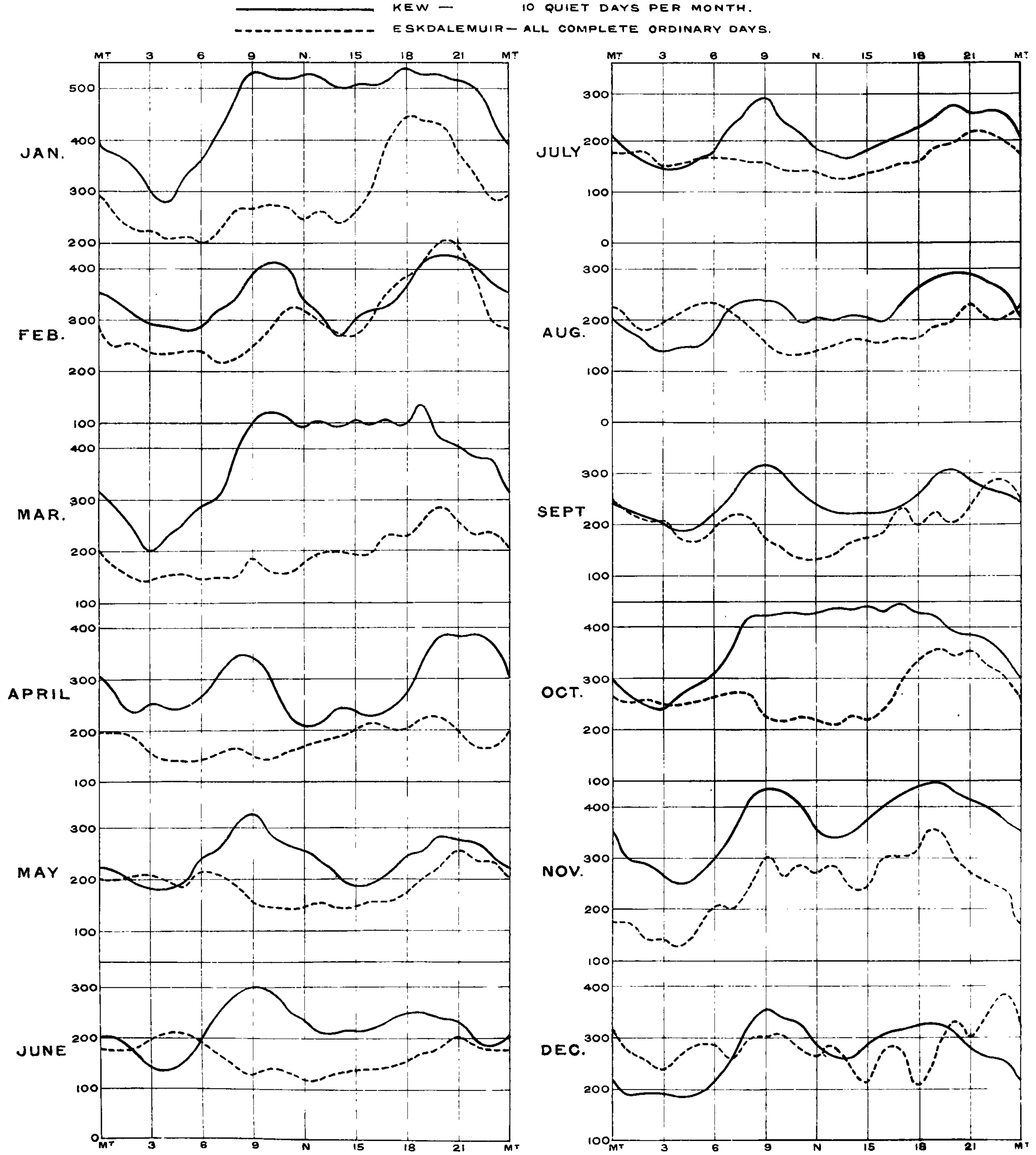
DIURNAL VARIATION OF POTENTIAL GRADIENT IN VOLTS PER METRE AT KEW AND ESKDALEMUIR, 1911.



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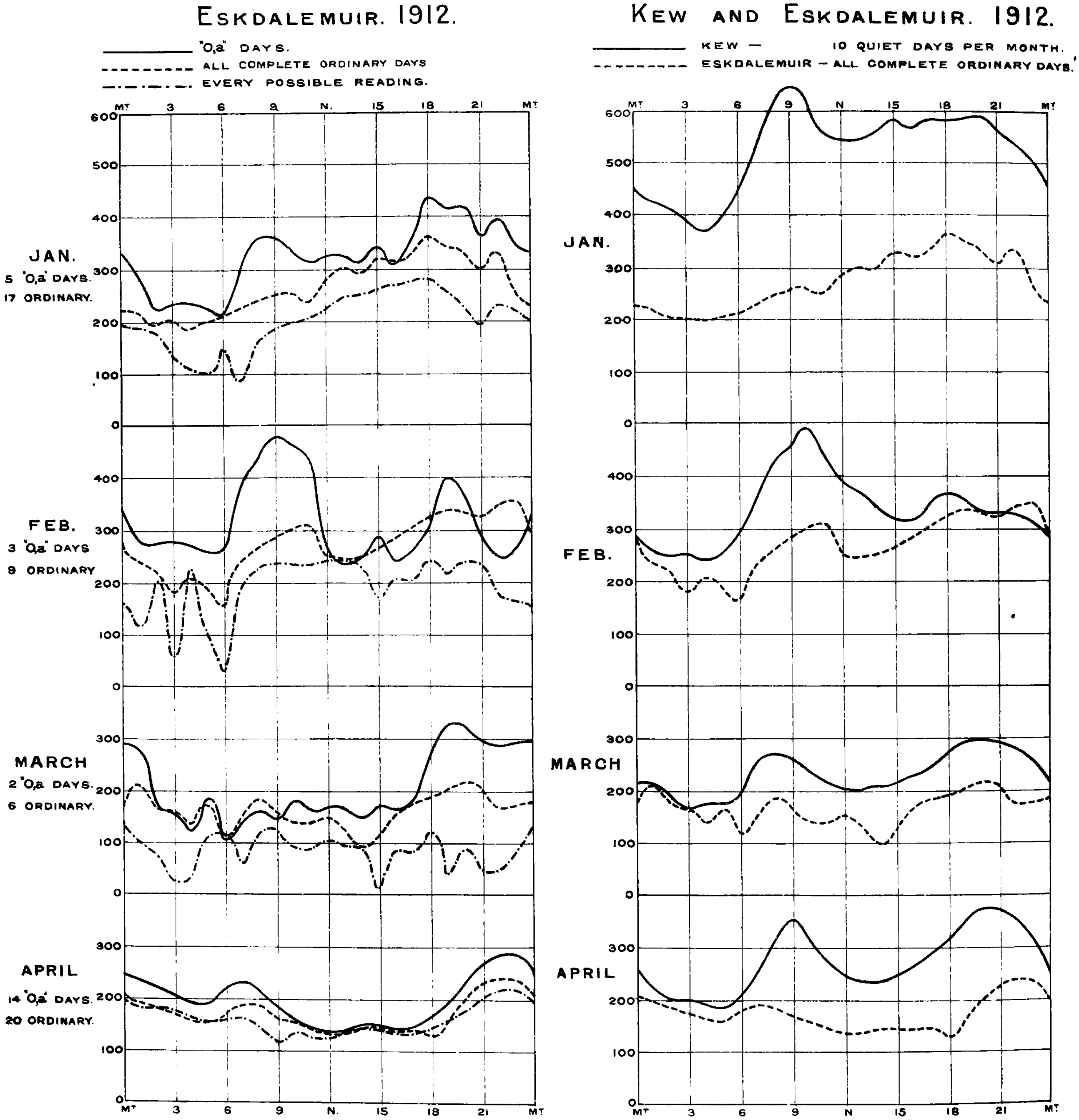
DIURNAL VARIATION OF POTENTIAL GRADIENT IN VOLTS PER METRE.



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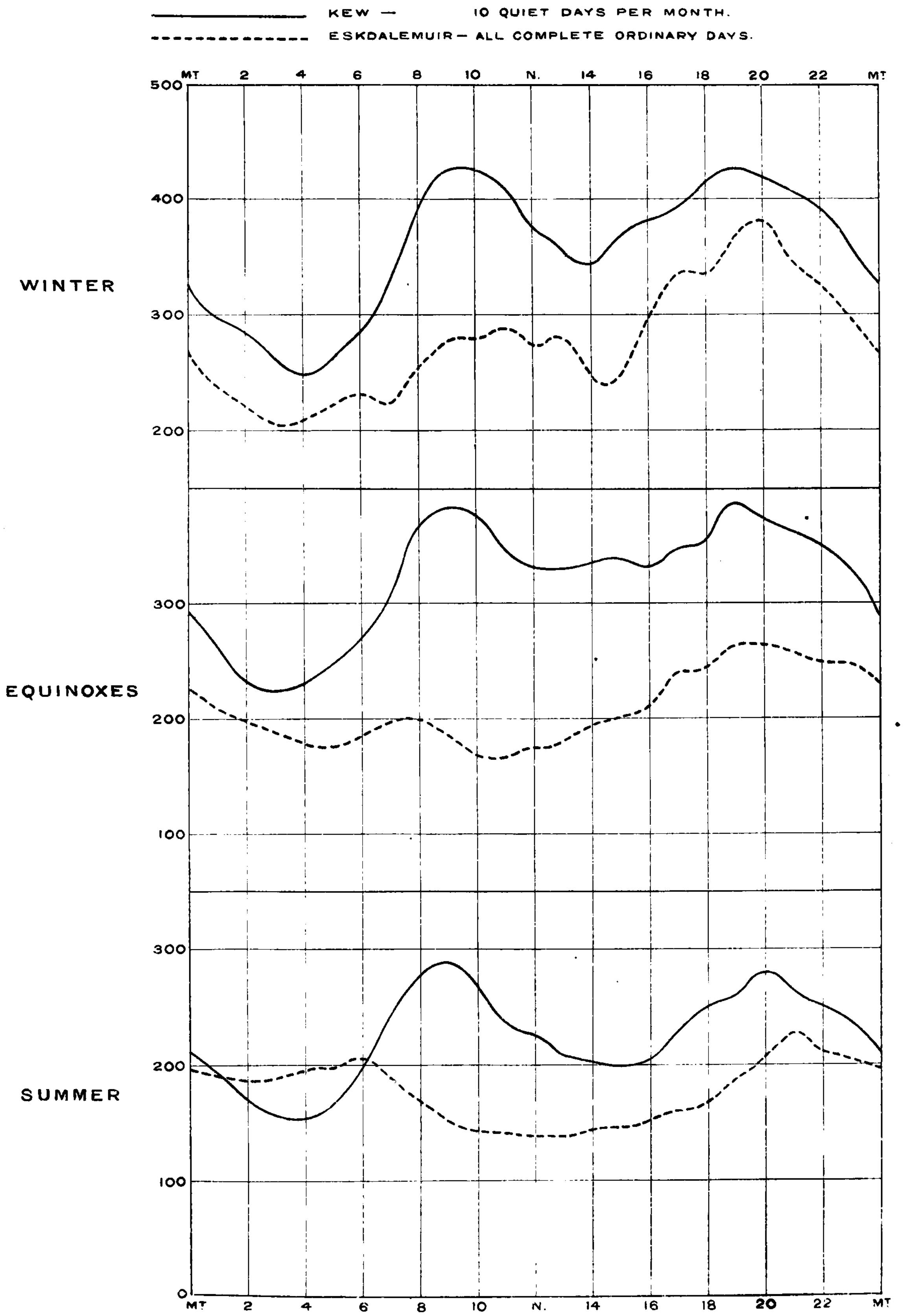
Diurnal Variation of Potential Gradient in volts per metre at Kew and Eskdalemuir, 1911.



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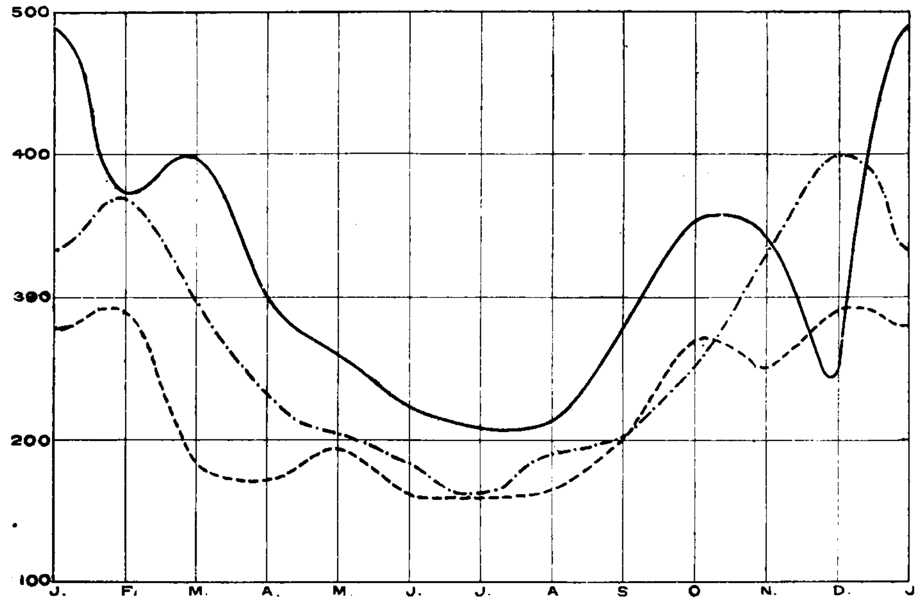
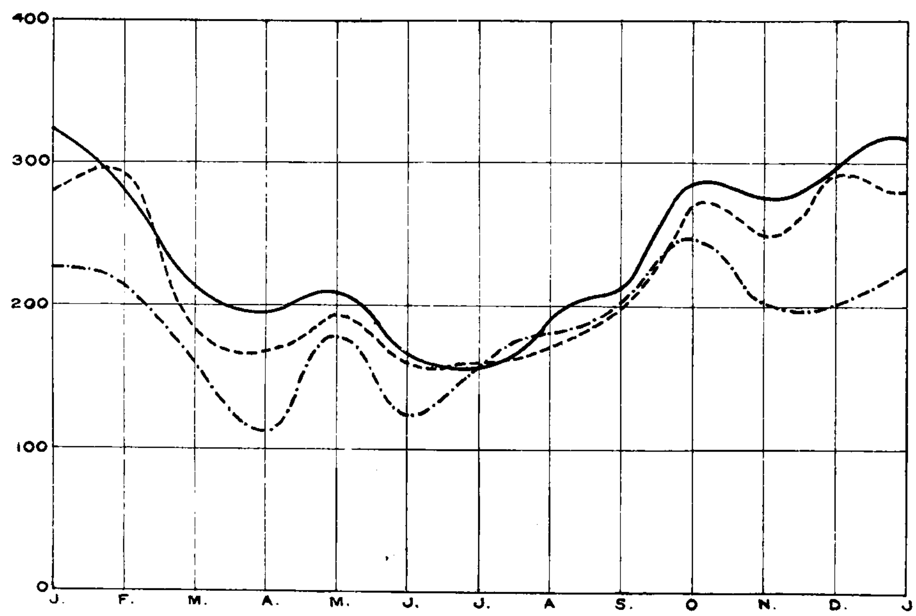
ANNUAL VARIATION OF POTENTIAL GRADIENT IN VOLTS PER METRE AT KEW AND ESKDALEMUIR 1911.

KEW — 10 QUIET DAYS PER MONTH 1911.
ESKDALEMUIR — ALL COMPLETE ORDINARY DAYS 1911.
KEW — 10 QUIET DAYS PER MONTH 1898–1911.



AT ESKDALEMUIR, 1911.

"O,a" DAYS.
ALL COMPLETE ORDINARY DAYS.
EVERY POSSIBLE READING.



40 1911. 1883/806/256. 3 825 6/8

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year 1911 and a few months of 1912, so that the period is really too short to obtain reliable figures. For this reason too much importance should not be attached to the curves for any particular month, but the seasonal results are probably a fair approach to those that would be obtained if a longer series of years could have been employed.

Diurnal Variation.—On Plates 28 and 29 are shown graphically the diurnal variation of potential gradient at both stations for each month, while on Plate 30 are shown the diurnal variations for the three seasons—summer, winter, and equinoxes,*—of the year 1911. As stated above, the data at Kew are from ten selected quiet days per month, and at Eskdalemuir from all complete 'ordinary' days.

The *winter* type of daily variation of potential gradient is very similar at both observatories. In each case two maxima and two minima occur in the day, and the times of these are nearly the same at both places. At Eskdalemuir the principal maximum and minimum are at 20^h and 3^h respectively, while the maximum and minimum near the middle of the day occur at 11^h and 15^h, but are much less marked. These late morning and early afternoon maximum and minimum are much more marked if only the '0, *a*' days are considered, but when all possible hours are included they disappear entirely, and the daily variation consists of a minimum at 3^h, followed by a steady rise to a maximum at 20^h, after which there is a rapid fall to the morning minimum. This naturally suggests that the type of variation might differ according to the character of the day. The short period during which observations were taken will not allow any satisfactory curves to be obtained from the disturbed days only, but it would seem that while the very quiet days of the '0, *a*' type give a double oscillation in the day, the more disturbed days have only a single oscillation. It should be noted that this applies to the winter months only. The curves for the variation at the equinoxes are very similar for each set of days. That this is not due to more disturbed days occurring in winter is shown by the fact that the number of '0, *a*' and of 'ordinary' days is very nearly the same in the two seasons.

Dr Chree has discussed† the electric potential gradient at Kew for the years 1898–1904. The curve for the winter season from this period of seven years is very similar to that obtained for the winter of 1911, so that this may be taken as fairly typical of the conditions at Kew.

It is not uncommon to find individual months at Kew which show only a single daily period, as January and March 1911, but in this case the type of variation is different from that obtained from all the days at Eskdalemuir, since after the minimum at 3^h the potential rises rapidly to about 9^h, after which it remains steady till about 19^h when it begins to fall again to the morning minimum.

Turning to the *summer* season we find the daily variations of potential gradient at Kew and Eskdalemuir no longer alike. At Kew the summer variation is not very different to that in winter, in fact the difference between the curves for summer and winter is remarkably small at Kew. But at Eskdalemuir the type of variation has completely changed. We now find that the potential is high and steady through the night hours, while after 6^h it begins to fall, reaching a minimum about noon, and then rising again

* The three seasons referred to include respectively the following groups of months:—For Summer,—May, June, July, August; for Winter,—November, December, January, February; for Equinox,—September, October, March, April.

† *Trans. Roy. Soc.*, Vol. 206. A.

until 21^h. There is evidence also of a slight depression a little after midnight, but it is only small, and may or may not be a real part of the true average variation.

It will be noticed that while at Kew two well-marked maxima and minima generally occur at every season of the year, at Eskdalemuir there is seldom more than one main oscillation. In winter the early afternoon minimum which occurs at Kew is only slightly marked at Eskdale, while in summer it is the early morning minimum which is almost absent at Eskdale.

At the *equinoxes* we find a type of daily variation at Eskdalemuir which may, perhaps, be regarded as a transition from the winter to the summer type. The principal maximum occurs at 19^h while the principal minimum is at 11^h. A small maximum and minimum also occur at 8^h and 5^h respectively. This curve is given by each of the three sets of days, and is very nearly the same in all the four months of the season. The curve for the equinoxes at Kew for 1911 is not in very good agreement with that obtained by Dr Chree from the years 1898–1904, the afternoon minimum being much less pronounced in 1911. This curve can, therefore, hardly be regarded as the normal one for the season at Kew. The irregularity is due to the fact that in neither of the months March or October was an afternoon minimum shown at all. How far the curve for Eskdalemuir is also abnormal it is impossible to say, but since each of the four months of this season give similar curves we may assume that they are reliable.

Annual Variation.—At Eskdalemuir we have only one complete year's records so that the yearly variation must be rather doubtful. As seen from the curves on Plate 31, the monthly means obtained from all possible hours do not give a satisfactory yearly variation. The curves obtained from the '0, α' days and the 'ordinary' days are much smoother. Taking again the curve from the 'ordinary' days as being the most reliable, we find a very similar yearly variation at both observatories, but the annual range is much smaller at Eskdale. The annual curve given by Dr Chree for the seven years 1898–1904 at Kew is also shown, and it is seen that throughout the year the gradient was higher in 1911 than for the above seven years. During this seven year period the method of taking absolute observations at Kew was different to that which has been employed since 1910, but allowance has been made for this. The value for December 1911 at Kew is very abnormal. Apart from this, the annual variation is very regular at both places; the minimum occurring in July and the maximum in winter. For the seven year period at Kew the potential is lower in January than in either December or February, but in 1911 the January value is abnormally high. A depression is also shown in January at Eskdale for the 'ordinary' but not for the '0, α' days.

Mean Absolute Values of Potential Gradient.—The mean potential gradient at Kew and Eskdalemuir for each season of the year 1911 is shown in Table V. All values are in volts per metre in the open as usual.

The mean value of the potential gradient at Kew is always higher than that at Eskdalemuir. The difference amounts to about 30 per cent. if the '0, α' days are used at Eskdale, or to nearly 40 per cent. if the 'ordinary' days are used. All the seasons show the same difference, and the ratio of the potentials at the two places is approximately constant throughout the year. (The value for December 1911 must be considered as quite abnormal.) Eskdalemuir observatory is situated at a height of about 800 feet above sea level, while Kew is practically at sea level. This may partly explain the higher potentials found at Kew. The chief cause, however, is probably to be found in the very low conductivity of the air at Kew, the value being very much smaller than that generally found at other places. This may be due to the large amount of dust and smoke in the air, owing to the nearness of London.

TABLE V.—MEAN POTENTIAL GRADIENT IN VOLTS PER METRE AT KEW AND ESKDALEMUIR, 1911.

1911.	KEW.	ESKDALEMUIR.		
	10 'Quiet' Days per Month.	'0, a' Days.	'Ordinary' Days.	All Days.
	v/m.	v/m.	v/m.	v/m.
Winter	359	294	278	212
Equinoxes	322	227	207	182
Summer	224	179	171	162
Year	302	234	219	185

There is of course the possibility that the difference may be only due to instrumental errors in the methods of taking the absolute observations. The methods actually employed are different at the two places, but the difference seems too large to attribute to this cause. It was hoped to compare directly the two methods, but opportunity could not be found.*

Comparison of Results at Kew and Eskdalemuir with those at other places.—It is of interest to compare the types of diurnal and annual variations obtained at Kew and Eskdalemuir with those obtained at other places. The variations of the potential throughout the day at some nine places are shown on Plate 32. When possible the variations in summer and in winter are shown separately, as they may be very different. In most cases only a few years' observations are available, and they were taken at very different times. The actual dates at which observations were made are shown on the curves. The absolute values of the potential gradient is often very uncertain, and for this reason the results have all been expressed as percentages of the mean values, not in volts per metre.

The *winter* variation is very similar in type at most of the stations, though the range varies considerably. The principal minimum occurs in the early morning about 4^h and the principal maximum in the evening about 19^h. At many stations there is also a secondary maximum and minimum near the middle of the day. This is especially well marked at Kew. The types of variation at Batavia and Tokyo are quite different to those at the other places. As would be expected at Batavia, situated near the equator, there is very little difference between summer and winter. Here the minimum near midday is always very strongly marked, while the early morning minimum is almost absent. At Tokyo the curve for the year presents the same features as that at Batavia, but in a less marked degree.

In *summer* the early afternoon minimum everywhere seems to be more marked than in winter. This is especially the case at Eskdalemuir and Paris, where it becomes the chief minimum of the day. It is interesting that in summer the type should change to one more like that obtained in the Tropics. The similarity between the

* It has since been found that the method used at Eskdalemuir gives results about 4 per cent. higher than that used at Kew.

curves for Batavia and for the summer at Eskdalemuir is very noticeable, though the range is much less at Eskdalemuir. It may be that the absence of an early morning minimum in the summer at Eskdalemuir is not the normal condition, and that, if a longer series of observations were available, the curve would be more like that at Kew. Each of the summer months, however, gives nearly the same curve, so that it seems probable that this is not the case.

At Potsdam and Davos curves for the daily variation of the conductivity of the air, and also of the air-earth current, are also available. At these places a well-marked afternoon minimum of potential gradient occurs in summer, but not in winter. Both at Potsdam and Davos, however, there is no marked rise of conductivity in the early afternoon which would correspond with the fall of potential gradient (*see* Plate 36). The effect is therefore not caused by a change in the conductivity of the air near the ground, and the variation of the air-earth current follows that of the potential gradient. An interesting difference is shown in the summer curves at the top of the Eiffel Tower and at the Bureau Central Météorologique near to it; while at the bottom the midday minimum of potential gradient is well marked, at the top it is quite absent and the morning and evening minimum and maximum alone occur. It has, therefore, been supposed that the cause of the afternoon minimum must be confined to the lowest layers of the atmosphere. The conditions at the top of a tower and on a hill are, of course, not at all comparable, but it is evident that Eskdalemuir observatory, situated at a height of 800 feet above sea level, is still below the layer which causes the decrease of potential in the early afternoon.

The curves for the annual variation of potential gradient at different stations are much more alike than those for diurnal variation. At almost all stations the maximum occurs in winter and the minimum in summer. Since the observations in most cases only lasted a few years the curves are not very smooth. The annual range varies considerably from place to place, those at Kew and Eskdalemuir being about the average. Three stations stand out as peculiar; both at Sodankyla and Batavia the maximum occurs in the spring and the minimum in late summer. There is nothing to indicate the reason for this. One station is situated in very high and the other in very low latitudes. At Helwan the potential is higher in summer than in winter. This, however, is explained by the effect of blown sand and dust from the desert in summer.

Conductivity and Ionization of the Air.

The electric potential gradient near the ground is the only electrical element which is continuously recorded at Kew or at Eskdalemuir. The only information about the electric conductivity of the air, the number of ions, and the air-earth current is derived from eye observations which are taken on fine afternoons about 15^h. At Kew there is a series of observations with the instrument designed by Mr C. T. R. Wilson, extending from 1909 to the present time with a gap of a year between April 1910 and May 1911. Since April 1911, observations have also been taken at Kew with Ebert's apparatus. At Eskdalemuir Wilson's instrument has not been used at all, but a number of observations have been made with Ebert's apparatus since 1909.

The instrument designed by C. T. R. Wilson * which has been used at Kew can

* *Proc. Camb. Phil. Soc.*, 13, 184, 1906.

be employed to measure both the vertical current passing from the air to the earth and also the electric potential gradient in the air; from these two it is possible to calculate the conductivity of the air. The instrument consists of a small insulated test-plate, connected to a gold leaf electrometer, and surrounded by an earthed guard-ring. The test-plate can be covered by a small metal cover standing on the guard-ring. A small sliding condenser is also connected, and is kept charged by a small Leyden jar. By means of this variable condenser, or 'compensator,' the test-plate system can be brought to any desired potential.

The method of using the instrument at Kew is as follows:—The instrument is placed on a stand with the test-plate about 1·5 metres above the ground. The cover is removed, thus exposing the test-plate to the electric field in the air, and the test-plate is connected to earth. A charge is thus induced on the test-plate which is proportional to the electric field immediately above it. The earth connection is then broken and the metal cover replaced over the test-plate, thus removing the electric field. The induced charge then raises the potential of the whole test-plate system. Knowing the capacity, the charge can be calculated from the potential, and from this the potential gradient immediately above the test-plate can be obtained. Next, after the 'compensator' has been brought to its zero position, and the test-plate momentarily earthed, the cover is removed at a known time. The potential of the test-plate is brought to zero by moving the compensator, and kept at this value for five minutes. During this time a small current has been entering the test-plate from the air. After five minutes the cover is replaced, and the compensator brought back to its initial position. The charge on the test-plate, due to the current from the air, is measured by the electrometer. Finally, the potential gradient is measured again, as at the beginning of the observation. Three to six of these observations are made in the afternoon and the mean is taken.

To calculate the air-earth current and the potential gradient from these results it is necessary to know (1) the capacity of the test-plate system; (2) the scale value of the electrometer; (3) a factor by which the results may be reduced to allow for the fact that the test-plate was not at ground level, but about one and a half metres above it. It is, however, not necessary to know any of these factors in order to calculate the conductivity of the air. Since the potential gradient can always be obtained from the electrograph this method has been employed. To obtain the air-earth current, the value of the conductivity is multiplied by the mean potential given by the electrograph.

A check on the accuracy of the observations can be obtained by finding the ratio of the electric field immediately above the test-plate to the potential gradient given by the electrograph. Such a test shows that the observations are generally satisfactory.

Professor Ebert's instrument is designed to measure the number of small ions of each sign and also their mobilities, and from these the conductivity of the air can be obtained. In this apparatus air is drawn through a vertical earthed tube, in the centre of which is an insulated rod connected to a Wulf electrometer. An air-meter measures the volume of air passed through. To measure the number of ions the central rod is charged to 150 or 200 volts, the potential being read by the electrometer. A known volume of air is then passed through, and since the electric field within the tube is very strong all the fast moving ions are driven either to the central rod or to the walls of the outer tube, according to their sign. The loss of charge of the central rod is a measure of the number of the ions of sign opposite to that of its own charge. A correction for leakage is also found by making an observation with no air passing through the tube.

In order to measure the mobility of the ions, a short metal rod is placed in the air current before it reaches the main central rod. This auxiliary rod is charged to 14 volts. As some of the ions will be caught by this rod, the number reaching the main rod will be smaller than before. Provided that the total number of ions remains the same throughout, the difference between the number of ions caught by the main rod, when the auxiliary rod is, or is not, in position, gives the number of ions caught by the auxiliary rod. Knowing the dimensions of the auxiliary rod, and the proportion of the total number of ions which are caught by it, it is possible to calculate the mobility of the ions.

There are two causes which make this observation for the mobility of the ions unsatisfactory. The first is that the number of ions constantly varies, just as does the potential gradient, so that the difference in the readings with, and without, the auxiliary rod does not really give the number of ions caught by that rod. It is for this reason that the observations not infrequently give negative results for the mobilities of the ions. The second cause is that the number of ions and their mobilities are too small for this method to work properly. Even when the values are highest the results are probably not accurate to within 20 per cent. A method which frequently gives negative results cannot be considered as anything but very unsatisfactory. More than half the observations at Kew give a negative result for the mobilities of the ions. The value is certainly very low at Kew, so that the results are less accurate than those at most places. For this reason, and owing to the absence of a complete year's results, the values of the mobilities have been considered too uncertain to be included.

Comparison of Mean Values at Kew and Eskdalemuir.—The number of observations at Eskdalemuir is too small to allow any curves for the yearly variations to be drawn, but at Kew, where the better weather conditions allow more observations to be taken, quite good curves can be obtained. These are shown on Plates 33 and 34. For comparison of the conditions at the two observatories, the results have been divided into two groups—summer and winter—in each year, and mean values for each group have been obtained. These are shown in Table VI.*

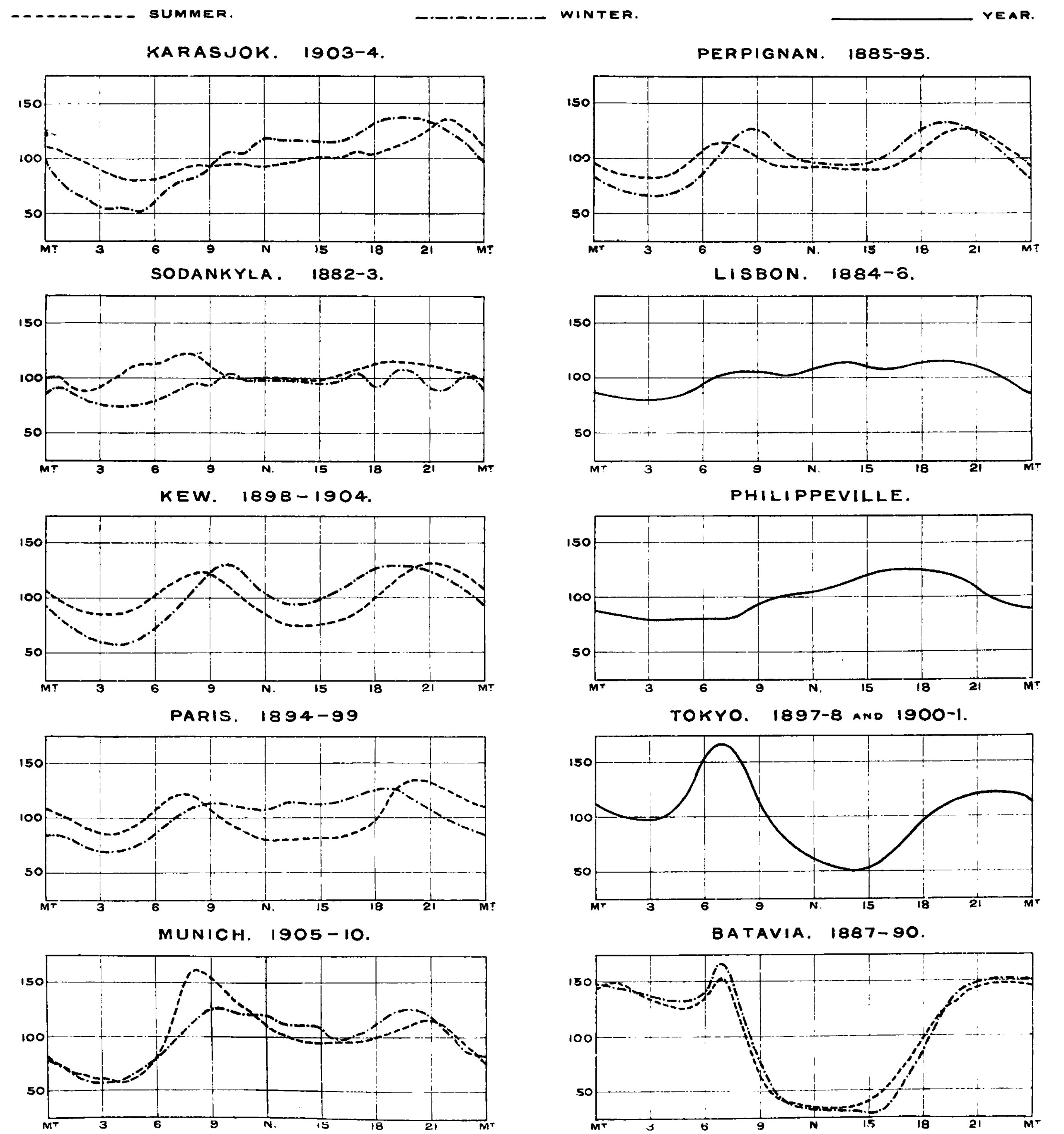
In this table $n+$ and $n-$ represent the number of positive and negative ions per cubic centimetre of air; $u+$ and $u-$ represent their respective mobilities in centimetres per second for a field of one volt per centimetre. The conductivity is expressed in E.M.U., but is multiplied by 10^{25}.

Several points in this table call for notice. Firstly, the results at Eskdalemuir vary considerably from year to year. This is no doubt largely due to the small number of observations. It shows that too much importance must not be attached to small differences. The small and uncertain difference between the number of ions at Eskdalemuir in summer and winter is very remarkable, especially considering the large difference at Kew, and the regular annual variation there. (*See* Plate 34.) In each of the three years the number of positive ions at Eskdalemuir has been greater in winter than in summer, but the number of negative ions has been greater in the summer

* The charge carried by one ion has been assumed to be $3 \cdot 4 \times 10^{-10}$ E.S.U. in the calculations of the number of ions.

Diurnal Variation of Potential Gradient in Volts per Metre at Ten Stations.

Expressed as Percentages of Mean Values.



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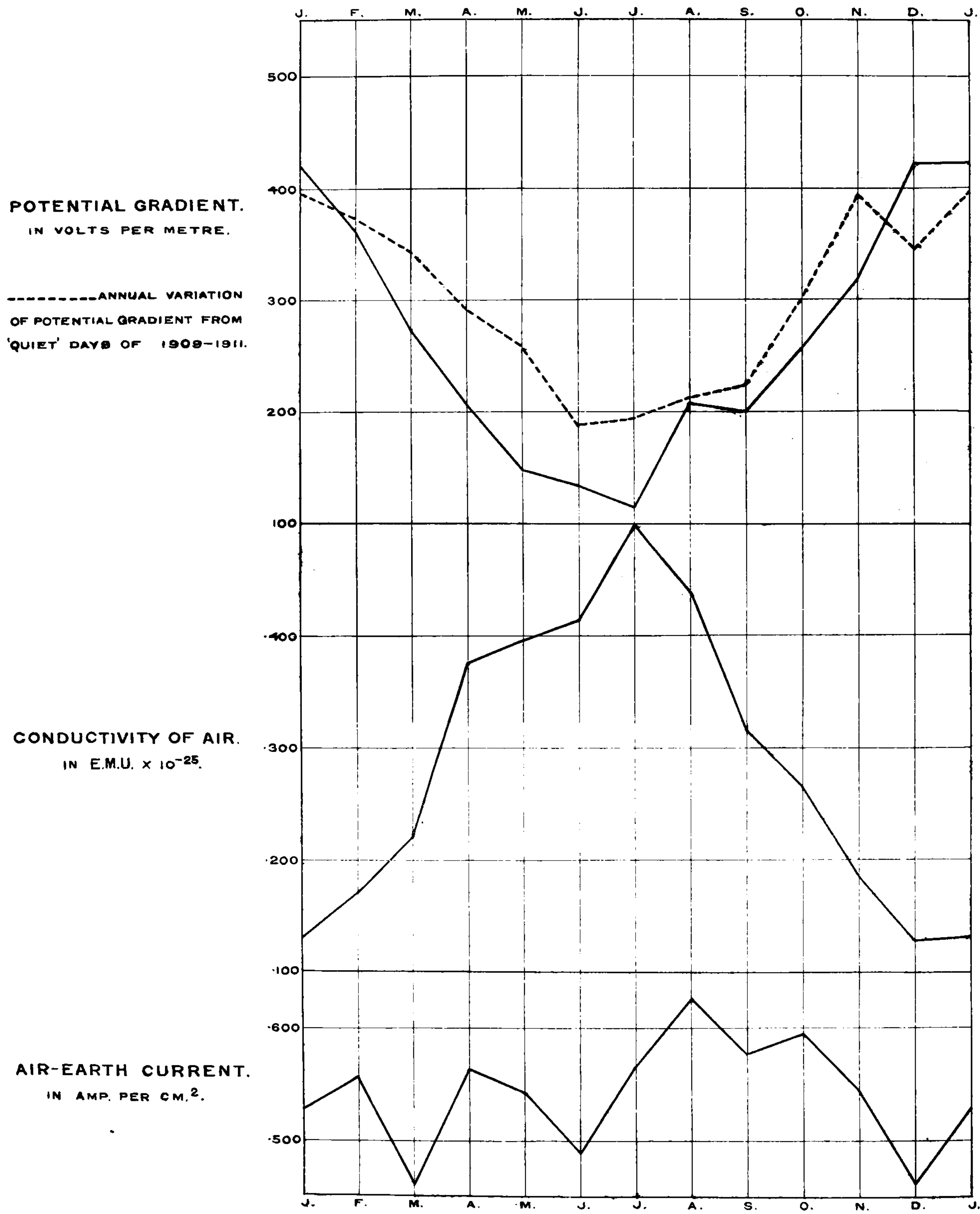
Annual Variation of Conductivity and Air-Earth Current at Kew. 1909-1911.

Measured by Wilson's Apparatus.



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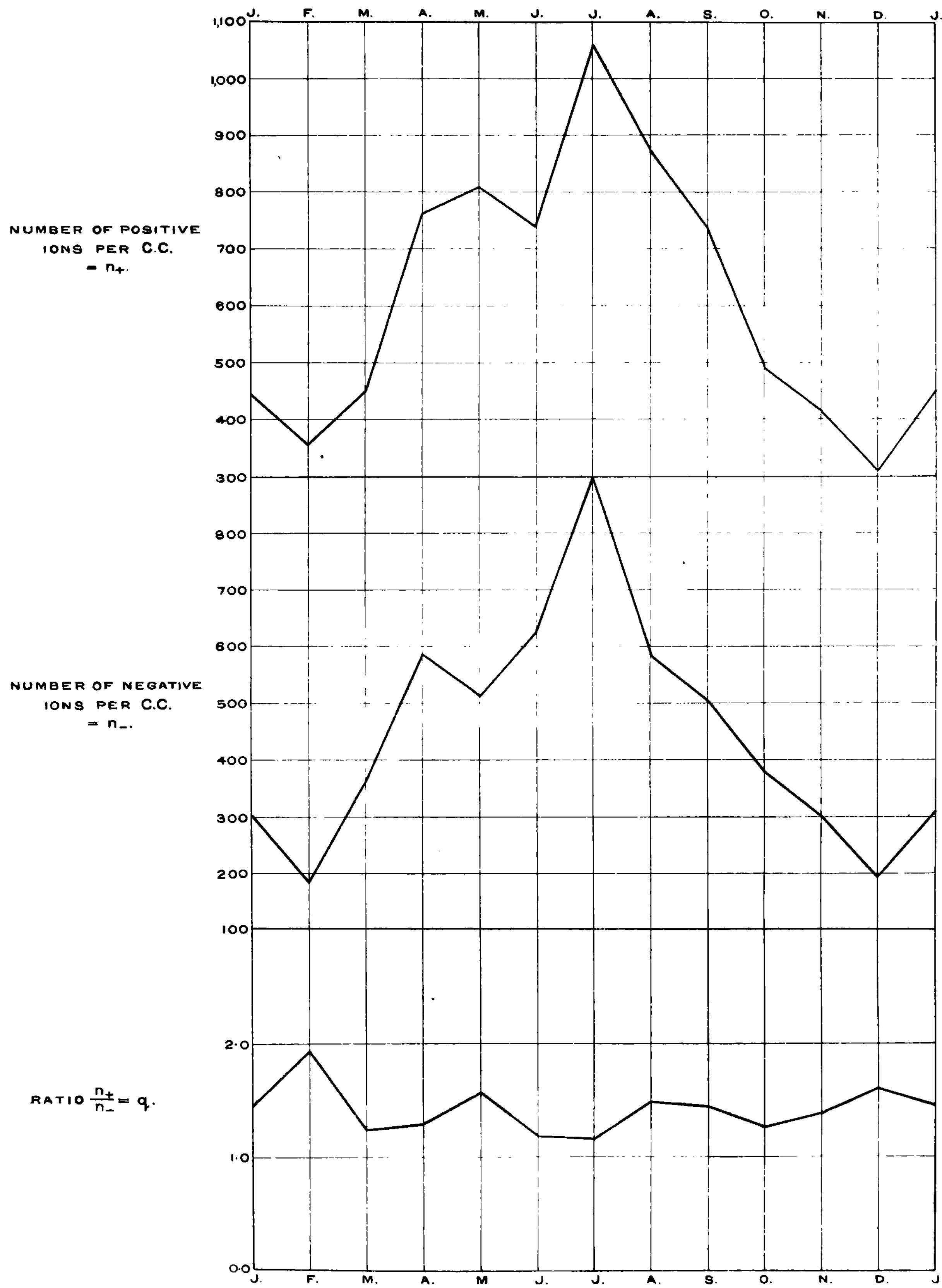
ANNUAL VARIATION OF THE NUMBER OF IONS AT KEW, 1911-12.



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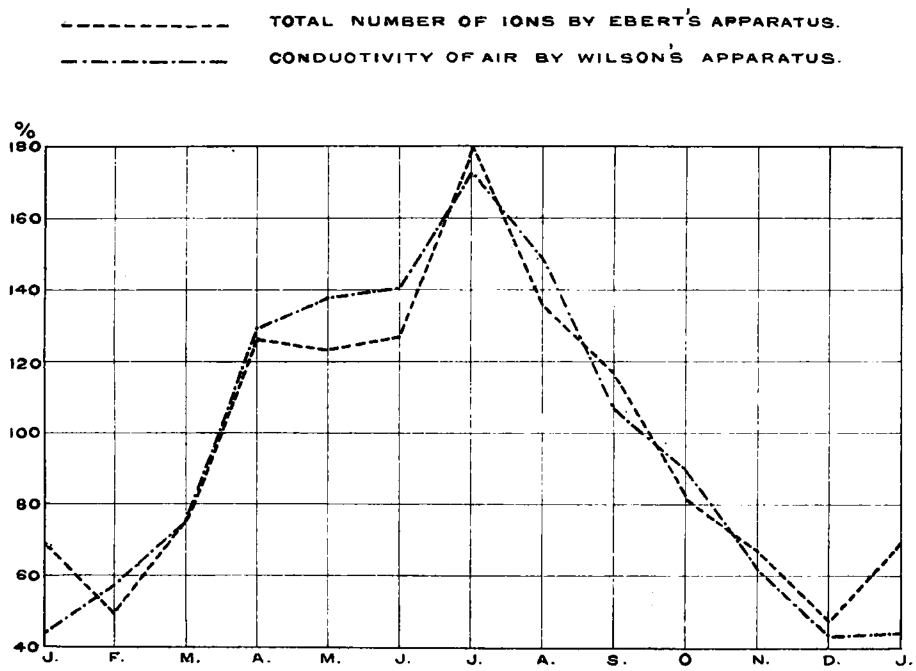
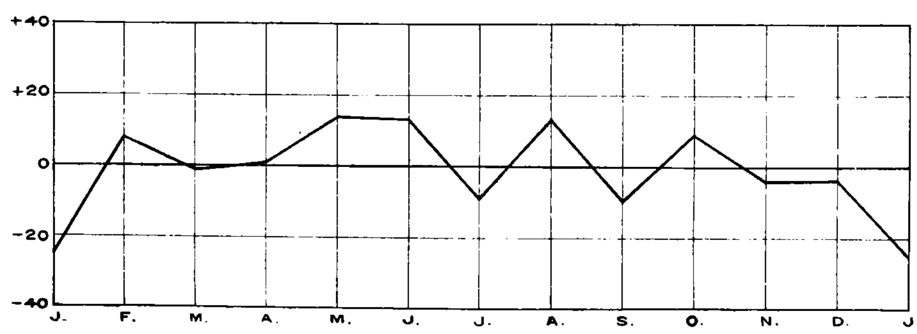
Annual Variation of Conductivity and Number of Ions at Kew.

Expressed as Percentages of Mean Values.



Difference between Monthly Percentage Values of Conductivity & Number of Ions.



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season. This, of course, causes a large difference in 'q' (the ratio of positive to negative ions) between summer and winter. The value of 'q' is rather variable, but a much larger value is always given in winter than in summer. This is also remarkable when compared with the constancy of this ratio at Kew, and the entire absence of any annual variation. (*See* Plate 34.)

Further, the values for the conductivity at Eskdalemuir are almost identical in winter and summer, while at Kew a very well-marked yearly variation is shown, the summer value being nearly double that in winter. (*See* Plate 33). The values of the air-earth current were not calculated at Eskdalemuir, since the electrograph was not

TABLE VI.—SUMMARY OF OBSERVATIONS FOR IONIZATION AND CONDUCTIVITY AT ESKDALEMUIR AND KEW BY MEANS OF EBERT'S AND WILSON'S APPARATUS.

		ESKDALEMUIR.				KEW.			
		With Ebert's Apparatus.				With Ebert's Apparatus.	With Wilson's Apparatus.		
		1909.	1910.	1911.	Mean.	1911–12.	1909.	1911–12.	Mean.
Number of Observations.	Summer	12	24	19	...	46	46	14	...
	Winter.	20	14	9	...	71	71	59	...
	Year	32	38	28	...	117	117	73	...
$n+$	Summer	382	404	602	463	840	...	...	...
	Winter.	534	478	636	549	461	...	...	...
	Year	458	441	619	506	619	...	...	...
$n-$	Summer	292	224	360	292	628	...	...	...
	Winter.	282	118	270	223	330	...	...	...
	Year	287	171	315	258	454	...	...	...
$q=\frac{n+}{n-}$	Summer	1·31	1·81	1·67	1·58	1·34	...	...	...
	Winter.	1·89	4·05	2·36	2·46	1·40	...	...	...
	Year	1·67	2·30	1·97	1·96	1·37	...	...	...
$u+$	Summer	0·90	1·20	0·84	0·98	...	...	...	...
	Winter.	0·96	0·79	0·82	0·86	...	...	...	...
	Year	0·93	1·00	0·83	0·92	...	...	...	...
$u-$	Summer	0·83	1·07	0·90	0·94	...	...	...	...
	Winter.	0·83	0·83	1·11	0·93	...	...	...	...
	Year	0·83	0·95	1·01	0·93	...	...	...	...
Conductivity.	Summer	0·59	0·78	0·82	0·73	...	0·37	0·49	0·43
	Winter.	0·79	0·52	0·90	0·74	...	0·20	0·23	0·21
	Year	0·69	0·65	0·86	0·73	...	0·28	0·36	0·32

working during the two earlier years; but since the conductivity remains constant, while from the year 1911 the potential gradient seems to have a well-marked annual variation, it follows that the air-earth current must also have a yearly variation similar to that of the potential with maximum in winter and minimum in summer. Again, comparing this with Kew, we find that here both potential gradient and conductivity have well-marked annual variations, but they vary in such a way that the air-earth current remains almost constant, the value being rather higher in summer than in winter.

We have no very good direct evidence of the annual variation of the mobility of the ions at Kew, but if we compare the curves for the annual variation of the conductivity with that of the number of ions we find the two are closely alike. Since the conductivity depends only on the number of ions and on their mobility, it follows that there can be no large variation in the mobility. Plate 35 gives the annual variations of the conductivity obtained from the Wilson apparatus and of the total number of ions (both positive and negative) obtained from Ebert's instrument. Both are expressed as percentages of their mean value. It is seen that the two are extremely alike. The lower curve gives, for any month, the difference between the two curves above (the percentage value of the conductivity minus the percentage value of the number of ions). If there were any regular annual change in the average mobility, this curve should show an annual variation. Except for a low value in January, which is due to a high value of the number of ions, the difference curve shows no sign of annual variation, from which we conclude that at Kew there is little or no annual variation of the mobility of the ions.

The values for the mobility obtained by direct measurement with Ebert's apparatus at Eskdalemuir also show very little difference between the values for summer and winter in any of the three years. This result is interesting because it is often supposed that the annual variation of conductivity is at least partly due to a decrease of the mobility of the ions in winter. It appears that no such change occurs at either Kew or Eskdalemuir, and that the well-marked annual variation of conductivity at Kew is almost entirely due to the change in the number of ions.

The number of negative ions is always much larger at Kew than at Eskdalemuir, and the difference is greater in summer than in winter. The mean number of positive ions for the year is also slightly greater at Kew; but while in summer it is much in excess of that at Eskdalemuir, in winter the Kew value is the smaller.

The values obtained for the conductivity of the air are always much smaller at Kew, where a Wilson instrument is used, than at Eskdalemuir where the Ebert apparatus is employed. This difference is more noticeable in winter than in summer owing to the marked annual variation of conductivity at Kew.

The large value of 'q' at Eskdalemuir is very abnormal. It is shown in each year, and even the summer value is considerably larger than that at Kew. Many observers have found that the value of 'q' becomes more nearly equal to unity the higher the station is above sea-level. This does not hold with regard to Kew and Eskdalemuir, though the latter is at about 800 feet, while Kew is practically at sea-level.

The small number of observations made in winter at Eskdalemuir may possibly account for some of the differences referred to above, especially as the number of observations near mid-winter is very small. The monthly means for the several electrical elements at Kew are given in Tables VII. and VIII. As before, the number of ions per cubic centimetre of air are given. The potential gradient is in volts per metre; the conductivity in E.M.U. $\times 10^{-25}$; and the air-earth current is in ampères per square centimetre multiplied by 10^{-16}.

The curves of the annual variation derived from the figures in these tables are shown on Plates 33 and 34. Considering that only one year's observations are available in the case of the number of ions and only two years in the case of observations with the Wilson apparatus, the curves are as smooth as could be expected. On Plate 33 the mean annual variation of potential gradient from the three years 1909–11, as deduced from hourly readings from the electrograph on ten 'quiet' days per month, is also shown. The agreement is not always quite close, but it shows that the general trend of the curves deduced from the Wilson instrument may be relied upon. The fact that the curve of potential gradient deduced for those hours at which Wilson observations were made shows a greater annual range than that from the means of the 'quiet' days may be explained by the fact that

TABLE VII.—RESULTS WITH EBERT'S APPARATUS AT KEW, 1911–1912.

	Number of Positive Ions.	Number of Negative Ions.	Ratio of Positive to Negative.	Number of Observations.
1911.				
May	806 per c.c.	514 per c.c.	1·56	7
June	737 ,,	625 ,,	1·18	10
July	1055 ,,	910 ,,	1·16	8
August	867 ,,	584 ,,	1·48	15
September	734 ,,	507 ,,	1·45	6
October	490 ,,	380 ,,	1·27	15
November	418 ,,	302 ,,	1·38	17
December	308 ,,	191 ,,	1·61	5
1912.				
January	444 ,,	305 ,,	1·45	10
February	355 ,,	185 ,,	1·92	4
March	499 ,,	361 ,,	1·24	8
April	760 ,,	585 ,,	1·30	13
Means	619 ,,	454 ,,	1·37	...

TABLE VIII.—RESULTS OF OBSERVATIONS WITH WILSON'S APPARATUS AT KEW, 1909–1912.

	Potential Gradient. Volts/Metre.				Conductivity. E.M.U. $\times 10^{-25}$.				Air—Earth Current. Amp./cm.$^2 \times 10^{-16}$.				Number of Observations.			
	1909.	1910.	1911.	1912.	1909.	1910.	1911.	1912.	1909.	1910.	1911.	1912.	1909.	1910.	1911.	1912.
Jan.	...	377	...	466	...	·138	...	·123	...	·522	...	·529	...	17	...	11
Feb.	433	342	...	318	·139	·197	...	·173	·516	·645	...	·508	5	11	...	5
Mar.	303	343	...	170	·158	·204	...	·299	·381	·587	...	·405	14	13	...	6
Apr.	207	...	...	...	·378	...	...	...	·564	...	...	...	14	...	...	...
May	147	...	...	...	·395	...	...	...	·543	...	...	...	15	...	...	...
June	134	...	...	...	·412	...	...	...	·488	...	...	...	15	...	...	...
July	104	...	123	...	·460	...	·565	...	·442	...	·692	...	14	...	5	...
Aug.	191	...	224	...	·359	...	·515	...	·625	...	1·067	...	3	...	4	...
Sept.	242	...	168	...	·239	...	·387	...	·543	...	·610	...	12	...	5	...
Oct.	189	...	326	...	·288	...	·245	...	·593	...	·595	...	9	...	10	...
Nov.	...	...	318	...	...	...	·186	...	...	...	·544	...	...	...	17	...
Dec.	496	...	346	...	·079	...	·176	...	·353	...	·568	...	7	...	11	...
Means	255				0·295				0·542				...			

the afternoon minimum, which occurs about the time the observations were made, is more marked in summer than in winter.

Annual variations of the potential gradient, conductivity and air-earth current have also been obtained at Potsdam, Davos, and Munich. At the two first places a recording instrument was used, and at the last, eye observations were taken about noon, when possible, with an instrument similar to that designed by C. T. R. Wilson. At each place observations have been taken for one year only. None of these three stations show annual variations as simple as that at Kew. (See Table IX. and Plate 36.) The variation of potential gradient is always fairly regular with a maximum in winter and minimum in summer. At Potsdam the conductivity of the air has two equal maxima in January and May, with minima in February and September. The variation of the air-earth current is something similar to that of the conductivity. In the case of all three elements the annual range at Potsdam is much less than that at Kew. At Davos the conductivity is high in summer and low in winter, but the summer maximum continues from June to October. The air-earth current is generally low in summer and high in winter, but there is a secondary minimum in January. At Munich the air-earth current seems to show a fairly regular variation, though the range is small. The minimum occurs in winter and the maximum in summer. The conductivity is higher in summer than in winter, but a very well-marked minimum occurs in July. Whether this would be shown if several years' observations were taken is doubtful.

The annual variation of the dissipation as found with an Elster and Geitel apparatus at Kew for the years 1907–9 is given in a paper by Dr Chree.* It is very similar to the curve of conductivity given by the Wilson apparatus though the range is not quite so large. If we take the air-earth current as being proportional to the dissipation multiplied by the potential gradient, then these observations show a small annual variation of air-earth current, the maximum being in winter and minimum in summer.

The monthly means of potential gradient, conductivity, and air-earth current at Potsdam, Munich, and Davos are given below. The units are the same as those used in the tables for the results at Kew. One of the most noticeable things is the very low mean values found at Kew for the conductivity and air-earth current. The conductivity at Eskdalemuir seems to be about normal.

TABLE IX.—MONTHLY MEAN VALUES OF POTENTIAL GRADIENT, CONDUCTIVITY, AND AIR-EARTH CURRENT FOR POTSDAM, MUNICH, AND DAVOS.

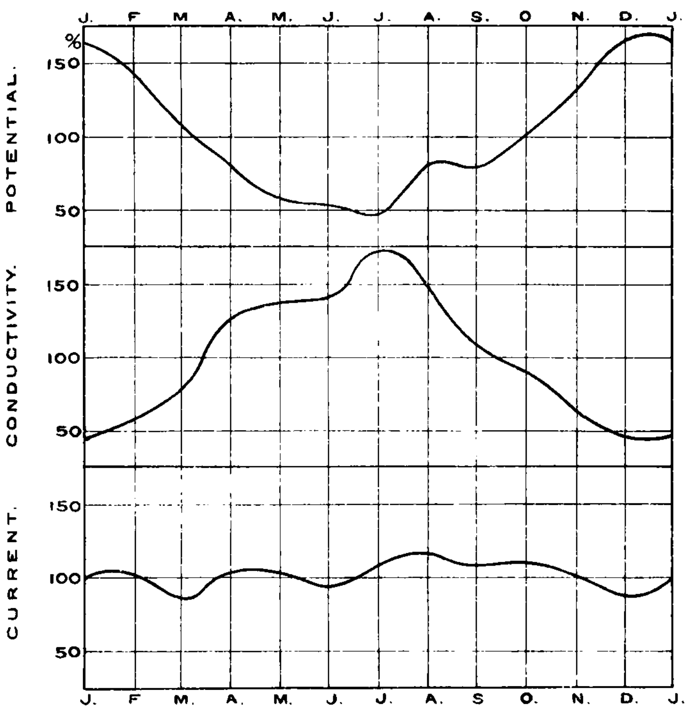
Month.	POTSDAM.			MUNICH.			DAVOS.			
	Potential Gradient. Volts/Metre.	Conductivity. E.M.U. $\times 10^{-25}$.	Air-Earth Current. Amp./cm² $\times 10^{-16}$.	Potential Gradient. Volts/Metre.	Conductivity. E.M.U. $\times 10^{-25}$.	Air-Earth Current. Amp./cm² $\times 10^{-16}$.	Potential Gradient. Volts/Metre.	Conductivity by + ve Ions. E.M.U. $\times 10^{-25}$.	Conductivity by − ve Ions. E.M.U. $\times 10^{-25}$.	Air-Earth Current. Amp./cm² $\times 10^{-16}$.
Jan.	242	0·600	1·36	482	0·430	2·07	105	0·95	0·78	1·7
Feb.	314	·354	1·06	514	·425	2·18	98	1·27	1·15	2·0
Mar.	272	·401	1·04	404	·362	1·46	94	1·20	1·09	2·0
Apr.	232	·525	1·11	216	·544	1·18	70	1·52	1·34	1·9
May	198	·590	1·11	157	·920	1·44	61	1·70	1·54	1·6
June	216	·576	1·23	150	·713	1·07	36	2·17	2·05	1·4
July }	216	·510	1·16	373	·349	0·95	49	1·82	1·60	1·4
Aug. }				259	·549	1·42	50	1·85	1·75	1·6
Sept.	261	·321	0·84	231	·699	1·61	51	1·87	1·67	1·6
Oct. }	315	·401	1·11	256	·505	1·29	49	1·99	1·79	1·8
Nov. }				402	·324	1·30	68	1·68	1·26	1·8
Dec.	341	·444	1·36	411	·517	2·12	102	1·00	0·81	2·0
Means	261	·472	1·13	313	·483	1·51	69	1·58	1·41	1·7

* *Phil. Mag.*, Sept. 1910.

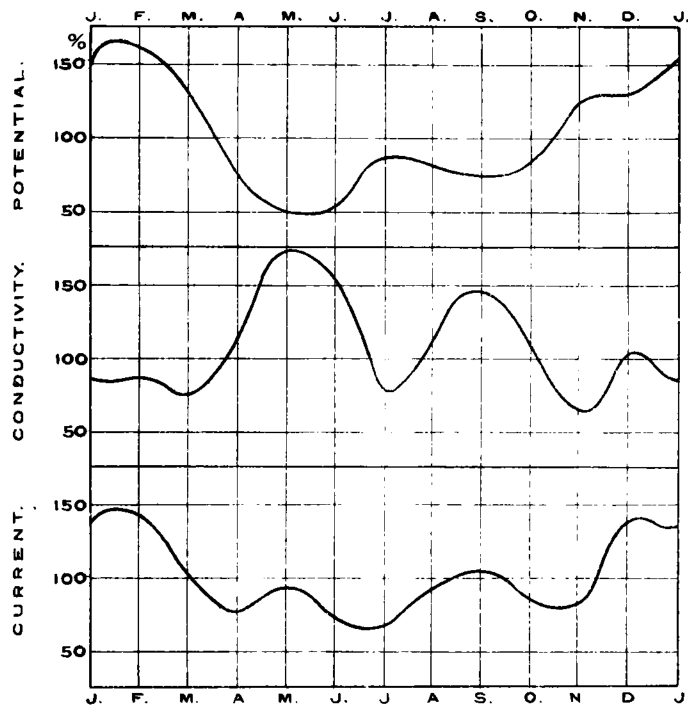
Annual Variations of Electrical Conditions at Four Stations.

Expressed as Percentages of Mean Values.

KEW. 1909—11.



MUNICH. 1909.



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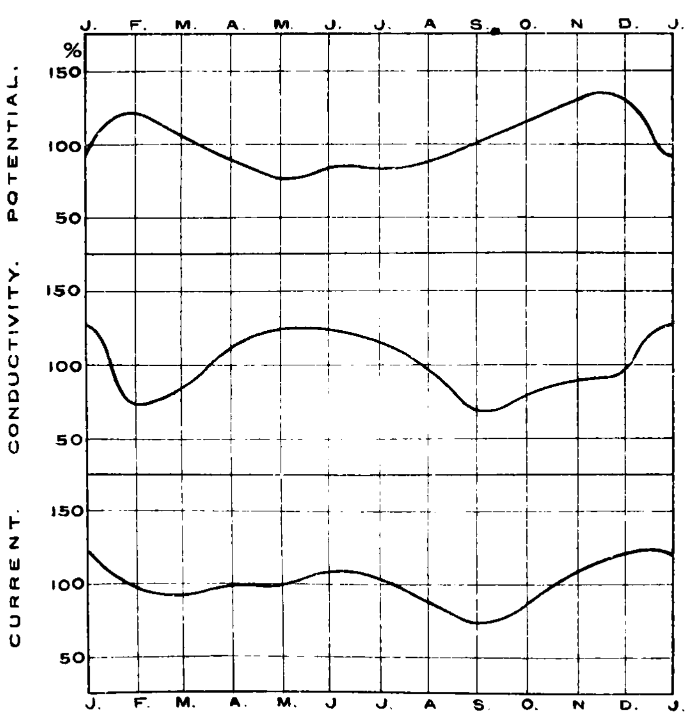
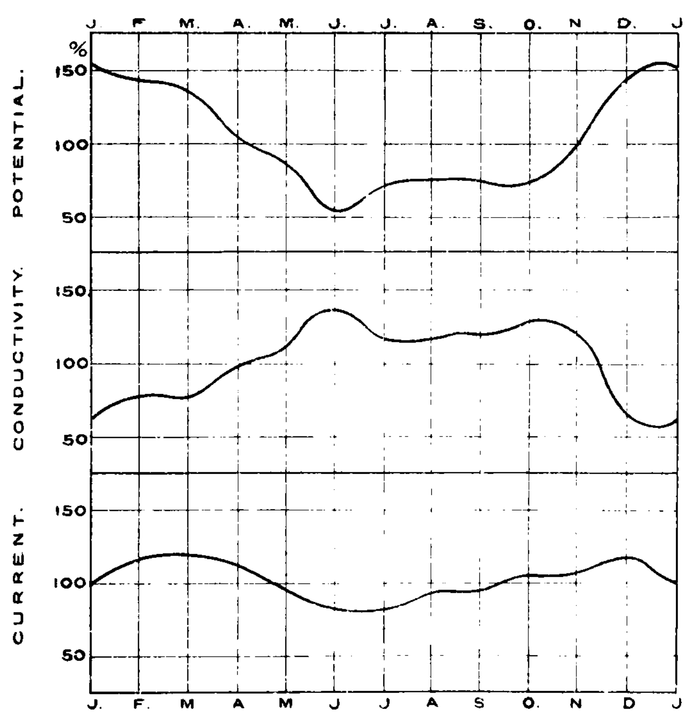


DAVOS. 1909.



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Effect of Meteorological Conditions on the Conductivity and Ionization.—In discussing the results of the observations with Elster and Geitel's dissipation apparatus at Kew for the years 1907–9, Dr Chree considered the effect of meteorological conditions on the results. It seemed best, therefore, when considering the effect of the meteorological conditions on the conductivity, air-earth current, and ionization, to follow the method used by Dr Chree, so that the results might be comparable. The method was to divide the days in each month in which observations were taken into two groups containing an equal number of days, the days in one group having the highest, and those in the other group the lowest values of the element considered. Means of the two groups were then found, and the difference between them expressed as a percentage of their mean value.

The number of observations is too small for this method of treatment, so that the results are uncertain. The two sets of observations with the Wilson instrument, the first taken by Mr J. S. Dines in 1910–11, and the other taken in 1911–12, were treated separately. The results, however, are not in very good agreement. Thus in the case of the effect of temperature, while the earlier observations seemed to show a fairly constant effect, the other set is very uncertain, and nearly half the months show the effect in one direction and half in the other. Under these circumstances the results cannot be considered sufficiently satisfactory. On the average a higher temperature seems to be accompanied by a higher value of the conductivity and a lower value of the potential gradient, while temperature seems to have little effect upon the air-earth current. A high value of the potential gradient also seems to be accompanied by a low value of the conductivity, and an air-earth current rather above the average. The effect of relative humidity seems to be very small.

The results for the ionization are hardly better than those for conductivity. The differences between the two groups of days are small and the results of individual months are often discordant. In general the ionization seems to be affected in the same manner as the conductivity.