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A SHORT HISTORY OF THE BRITISH RAINFALL ORGANIZATION

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PREFACE

This paper is based on a presentation made at the 150th Anniversary Meeting of the Royal Meteorological Society, held at the Royal Society, London, 3-4 April 2000.

A short history of the British Rainfall Organization

Royal Meteorological Society, 104 Oxford Road, Reading, RG1 7LL, UK

SETTING UP

During the mid-1850s, a sequence of dry years in Britain led to public concern over the possibility of permanently decreased rainfall. In 1859, the then President of the Scottish Meteorological Society, the Marquess of Tweeddale, offered a £20 prize for the best essay on 'whether the amount of rainfall in the western parts of Europe, and particularly in Scotland, is less now than it formerly was' (Scottish Meteorological Society 1859). In his prize essay, published the next year, Thomas Jamieson, of Ellon in Aberdeenshire, concluded that there was neither increase nor decrease in the average for 22 stations (Jamieson 1860). However, James Glaisher had said, in the Registrar-General's Quarterly Return for June 1859, that 'from a careful examination of the fall of rain from the year 1815, it would seem that the annual fall is becoming smaller, and that there is but little probability that this large deficiency will be made up by excesses in future years' (Glaisher 1859). Different conclusions of course illustrate the care needed to distinguish an average over an area from that of a single station, for Glaisher had used the records from Greenwich alone.

Glaisher's comments had drawn the attention of a young meteorologist, George James Symons (Fig.1), who had joined the British Meteorological Society in 1856, at the age of 17. Within two years, Symons had published his first paper – on thunderstorms in 1857 – using 'a small organization analogous, but naturally inferior, to the one recently started by the Society' (Symons 1889). This work was extended another two years in a paper presented at the British Association meeting in Oxford in 1860. It had involved the collection of rainfall statistics, but it was Glaisher's comments that encouraged him to make the effort to collate existing records, for there had been no general collection of all reliable records and no thorough investigation of rainfall trends (Symons 1863). Circulars were sent to observers of the British and Scottish Meteorological Societies and to all others known to keep records. Results for 1859 he published next year in a magazine, *The Builder*.

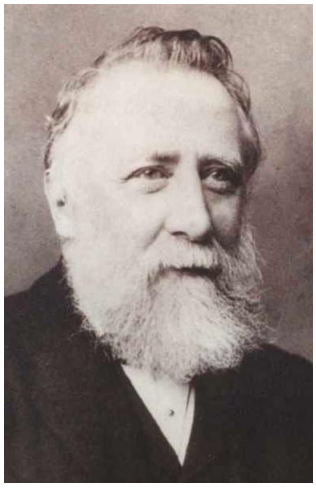

Fig.1
George James Symons

In 1860, Symons started work as a clerk in the newly-established Meteorological Department of the Board of Trade, under Admiral FitzRoy (Mill 1938). He was struck by the supreme inadequacy of available observations of rainfall but his studies had to be confined to leisure hours, for FitzRoy did not consider the work to be suitable to occupy official time. At the end of that year, Symons sent a circular to all the observers he knew of in England stating that he had commenced 'the somewhat Herculean labour of collecting the published and unpublished results [of rainfall observing] (Mill 1902)'. This led to a pamphlet, *English Rainfall 1860,* containing the records from 168 stations (Symons 1885).

He had thought that *collection* of records would 'require little besides perseverance and careful work' (Symons 1863), but he 'soon discovered that collection was no easy matter' (Symons 1867). Even so, it had become 'the primary object I had in view' – *publication* was secondary (Symons 1866). By 1863, he had tabulated monthly falls at 900 stations, the earliest back to 1677. He considered the very old observations were 'far more reliable than many modern ones, for in the 17th and early part of the 18th centuries the measure of the fall of rain was esteemed a serious undertaking, only to be accomplished by first-class men' (Symons 1866). Old observations were not to be used to determine means but they could indicate long-term variation.

EXPANSION

In 1862, Symons began inspections of gauges to test accuracy, to measure height of rim above ground and above sea-level, and to give advice (Symons 1863, 1867). He managed to get to 40 stations in that year (1863[1]), and more than 400 within ten years (1871). Visits were warmly approved by observers, but they could be made only during vacations (1863), and they involved 'an amount of travelling which takes far too much time and too much money to make any great progress with it'. According to Isaac Fletcher, who had set up 12 well-concealed gauges in Cumbria, Symons, in the autumn of 1866, 'cruised for hours among the rocks and defiles of Wasdale Head and the Styehead Pass in search of my gauges. He could not find one of them' (1868).

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[1] References by year alone are to the many unsigned statements in *British Rainfall* by year of publication – i.e., immediately following the year of observations.

By 1863, when he was elected to Council of the British Meteorological Society, development of the work was so rapid that it could no longer be undertaken as a hobby, even though the whole of his leisure time was devoted to rainfall (Symons 1863). Symons had to choose between paid office work and unpaid rainfall work. He chose the latter, and so resigned from the Meteorological Department at the end of the year, 'unpleasant as it was financially' (1864). Time now became available so that 'steady pursuit of lines of research [his phrase] may develop practical use in manufacturing, engineering, agriculture and sanitation'. Symons had decided on his life's work.

His workload increased quickly. In that year, the number of gauges had increased more than five-fold (1864), but their distribution was uneven, so a letter was sent to *The Times* asking for recruits in out-of-the-way places. Replies poured in daily – so many, in fact, that Symons had to refuse some on grounds of lack of funds. Even so, a hundred new stations were started through that letter (1867). Two years later, in 1865, a circular was sent to more than 1400 local newspapers asking for records, old and new. Each circular was tailored to a particular area and each passed through Symons's hands – 'a long and most tedious process', he said (1866). The results were negative rather than positive. Although there were many hundreds of replies, only a small proportion contained any old records that had not been already collected. However, about 200 said they had recently procured a gauge and would be happy to supply records. Now there were over 1200 places recording rainfall. From the returns, Symons made several inferences (1866): that nearly all known observers were then working with him; that few old observations could be collected except by diligent search in publications and private manuscripts; that missing observations were irretrievably lost; and that every stray observation should be treasured. Old records continued to surface. For example, in 1866 he was made aware of 50 years of records from 25 lighthouses under the control of the Board of Northern Lights (Symons 1866).

By 1870 he was able to give an updated account of the variation of rainfall in England since 1725 – the reason for starting his life study (Symons 1871). He showed that the dry years of 1854-8 were, in fact, unimportant compared with the years 1800-09, and more particularly 1738-50 – thus illustrating the value of serendipity: in this case, the chance discovery that a great observing network could be built up on voluntary effort, despite being founded on a false premise. However, lack of funds persistently thwarted Symons from completing the work. In 1883, he was still saying 'I have pointed out over and over again that there are abundant statistics to determine the rainfall for upwards of a century before I began. This work stands still for want of £200 or £300 a year to be expended in additional assistance, and I believe could be completed in about three years' (1884).

The progressive increase in the number of stations created ever more work, of a kind now well known to any meteorological service: testing of gauges before despatch; gauge inspection (the most troublesome work – involving 'a species of zigzag pedestrian tour' as he put it (Symons 1867); keeping a history of each gauge; supplying of forms; collecting, checking and tabulating records; calculating totals and averages; corresponding with observers, particularly on lateness or errors, and providing advice (more than 4,000 letters and postcards a year by 1880); making recommendations on gauge type and siting. In 1866, Symons said 'I feel as if I was gathering volume after volume of rainfall observations and yet deducing no results' (Symons 1867). He appealed for assistance: 'Perhaps some careful person, who does not mind voluminous work, will relieve me of one or other of these discussions' (Symons 1867). By 1871, there was no time for anything but routine work (1872). Even so, he was made Vice President of the British Meteorological Society in that year, and found time to become its Honorary Secretary in 1873, following the resignation of Glaisher (Anon. 1900b). Recognition of his great contribution to the understanding of British rainfall came in 1878 with election to Fellowship of the Royal Society.

OBSERVATION METHODS

It had become clear from the outset that there was a need to standardize gauge design and usage. Symons had already started experiments into the effects on catch of variations in gauge size and shape, back in 1858 in his own garden (1908), greatly encouraged by his mother. In 1863, Symons took up the offer of Michael Foster Ward, of Calne in Wiltshire, to undertake more extensive investigations, including the effects of gauge elevation above the ground. In that year, he wrote to Alexander Buchan, Secretary of the Scottish Meteorological Society, expressing a wish to include a gauge recommended by that Society (Fig.2 - see pages 4 and 5). Buchan replied (Fig. 3 - see pages 6 and 7), after admitting that they had no pattern gauge for want of 'experiments to determine the best gauge and its proper height', saying that he would send two types of gauge (but they would take a day or two to make!). By involving Ward, and subsequently others at various places around the country, the experiments continued until 1890 (Mill 1901, Salter 1921). Fig. 4 (see page 8) illustrates the array of gauges used on his lawn by Ward, who continued his observations until 1867, when the

gauges were transferred to Stratfield Turgis in Hampshire, under the enthusiastic supervision of the Rev. C H. Griffith, whose layout is shown in Fig.5 (see page 9).

The experiments were remarkable for their planning, execution and the drawing of conclusions. Results, such as those shown in Fig. 6 for 1865 (see page 10), led to the progressive adoption of the well-known standard gauge, still used by the Met Office: one made of copper, with a five-inch funnel having its brass rim at one foot above the ground, and a glass container to collect the rain. He said that 'a clear, open grass plot (a good croquet ground!) is the proper place for a rain gauge' (Symons 1867). It was confirmed that the long-known decrease of catch with height was, as suspected, a result of wind eddying around the gauge; hence the need for shelter, particularly at exposed sites. Lack of agreement between records was mainly owing to this cause (Salter 1921). In-splashing also seemed to be significant with rims less than one foot above the ground. On size of gauge, Symons, in responding to criticism in the *Mechanics Magazine* that he advocated the use of small gauges, said that the experiments had shown that a five-inch gauge records the same as one 20 times the size – 'a fact which I have the pleasure of submitting to the advocates of washing tubs instead of pipkins' (1867).

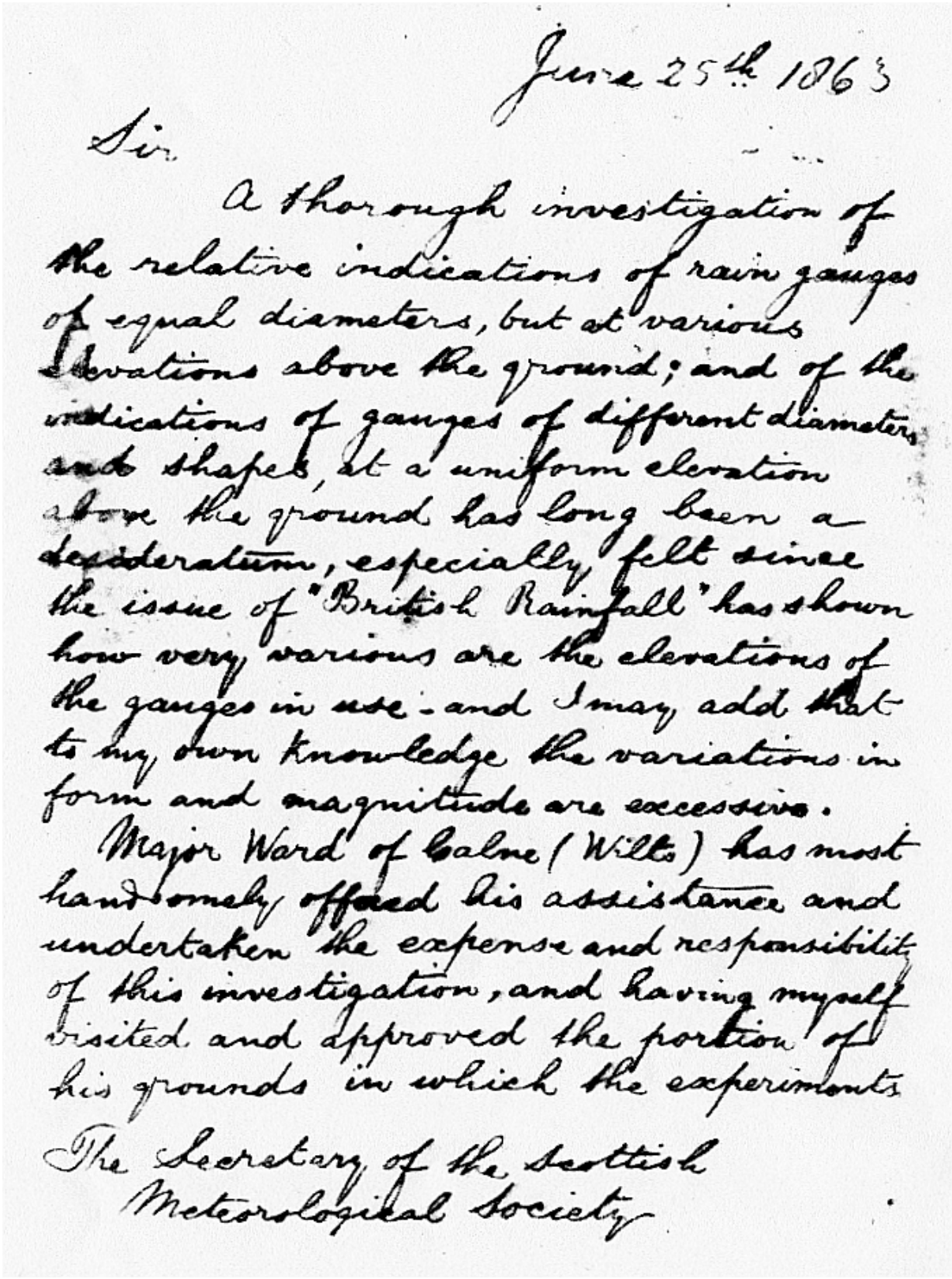
A matter that provoked much discussion was the definition of 'rainy day'. There was at first a great variety of definitions used by observers, according to amount or duration of fall. Amount could be whether it was measurable, or more than 0.01in, or simply enough to wet the stones. Duration could be more than 1hr, or 6hr, or the greater part of the day, or simply that which prevents outdoor work for 6-8hr. By 1866, it had been agreed with the observers to abolish the term 'rainy day' and to record the days with 0.01in or more (Symons 1867); and by the same year it was also agreed that the fall should be measured at 9am and the amount entered against the previous day, rather than the day of reading as had been recommended previously by Glaisher until persuaded otherwise (1865, 1866). The latter rule was 'based on the practice of the majority, ascertained by a species of voting, and ratified by the Councils of the British and Scottish Meteorological Societies' (Symons 1867).

PUBLICATION

From the start, Symons planned to publish the records coming from the expanding network of gauges. The pamphlet for 1860 was in such demand that Symons 'resolved to publish one annually in future' (1862). A reprint of the amounts for 1860, along with those for 1861, formed the first volume in the famous series of *British Rainfall*, containing 168 stations. These annual summaries were supplemented towards the end of 1862 by *Monthly Circulars*, containing 20 stations (later to increase to 40), for which Symons requested prepayment from those wishing to receive copies (3s from observers, but 5s from others) (1863). In December 1865, Symons stated that 'with this issue my little *Monthly Circular* ceases, but only to assume, with its new name [*Symons's Monthly Meteorological Magazine*] a more permanent form, a larger size, and a more comprehensive scope next month' (1866), at a price of 5s a year. This change seems to have been prompted by an increasing number of contributions from observers. The *annual* summary would continue, but he proposed 'if adequately supported, to give the *monthly* fall at every station in each county, with as full a description as possible of the kind of rain gauge, its position, the locality, etc, noticing every record ever kept. The cost of printing this large work (at least £200 or £300) will prevent its being attempted for many years to come, unless fresh sources are found to supply the funds' (1867). By 1867, Symons had gathered sufficient material on the history of rain gauges and recording that he was able to write a book entitled *Rain: how, when, where and why it is measured* (Symons 1867).

British Rainfall was published in February or March during the first ten years, but the delay increased, partly through the greater volume of work without additional assistance, and partly through delays caused by some observers. For example, about 100 returns for 1866 had not been received by mid February (1867). Of course, there was greater difficulty in getting records from some places rather than others – such as the Hebrides and Shetland. In 1870, Symons complained that the 'waste of time and worry produced by returns of about a dozen observers, who seem unable to cast a single column of figures and whose returns are consequently continually travelling backwards and forwards, is so great that I have resolved henceforth to exclude the returns of all those individuals who, in three consecutive years, send in returns cast up incorrectly' (1871). Symons was being perhaps somewhat harsh, bearing in mind the educational level of some of his observers for, as he had said, they were of all ages and classes (1864).

continued on page 11



June 25th 1863

Sir

A thorough investigation of the relative indications of rain gauges of equal diameters, but at various elevations above the ground; and of the indications of gauges of different diameters and shapes, at a uniform elevation above the ground has long been a desideratum, especially felt since the issue of "British Rainfall" has shown how very various are the elevations of the gauges in use - and I may add that to my own knowledge the variations in form and magnitude are excessive.

Major Ward of Calne (Wilts) has most handsomely offered his assistance and undertaken the expense and responsibility of this investigation, and having myself visited and approved the portion of his grounds in which the experiments

The Secretary of the Scottish
Meteorological Society

Fig.2 (this page and opposite page): Letter from Symons to Buchan requesting a gauge to be added to the experiments to be conducted at Calne (from the Royal Meteorological Society archives).

will be conducted, I feel satisfied that the results may be accepted with the greatest confidence.

It is proposed that the elevation series shall consist of 8 inch gauges at 20ft, 10ft, 5ft, 3ft, 2ft, 1ft, 6in, 2in and level - also a 5in gauge at 20ft.

The Magnitude series will consist of circular gauges 24in, 12in, 8in, 6in 5in 4in 2in and 1in diameter, and of 10in and 5in square.

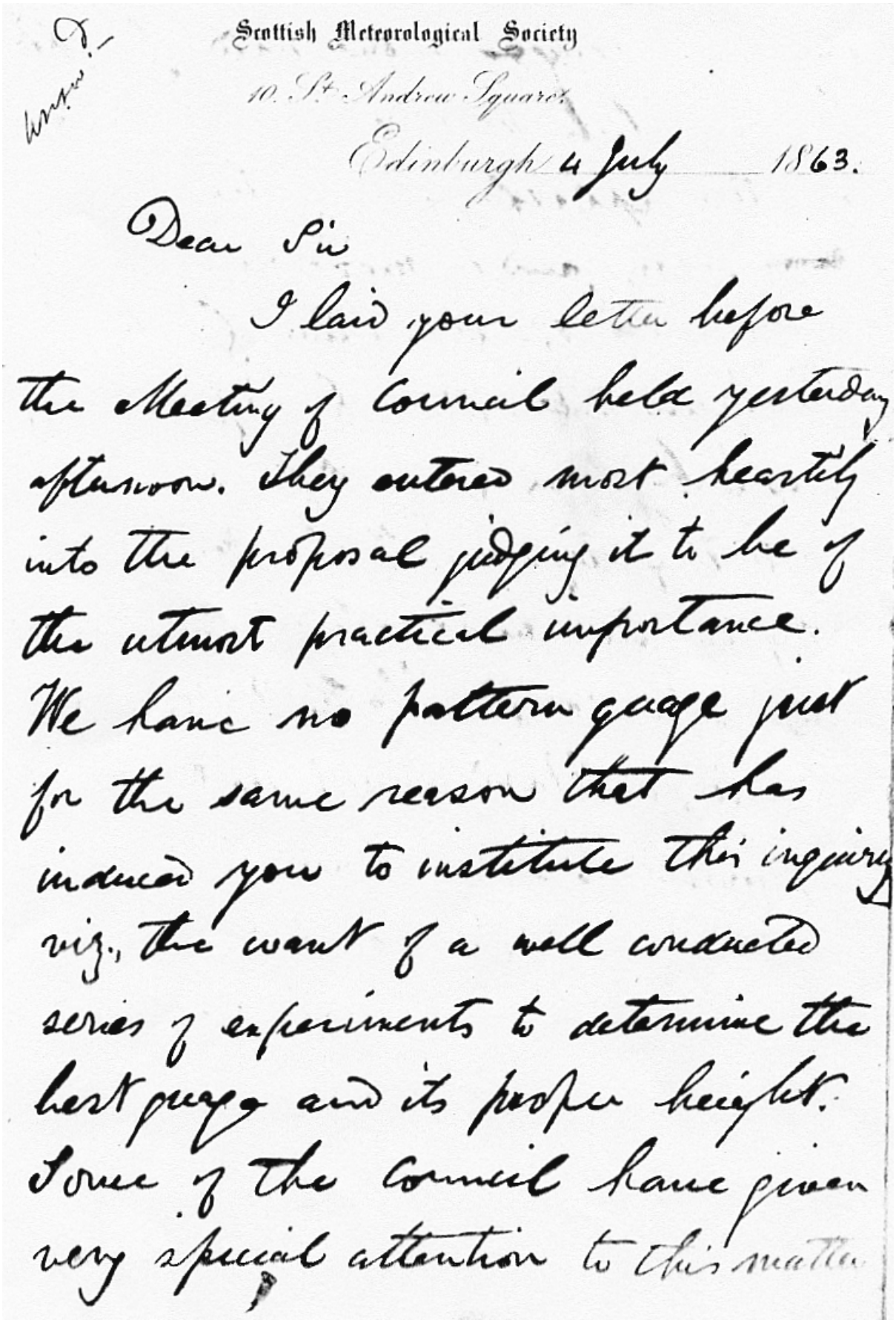
I am very anxious that the form of gauge recommended by your Society should be added to the series, a desire in which I presume the Society will concur - I therefore trust that they will order a representative gauge of certified accuracy to be forwarded to me as soon as possible, as I go to Ealne in a fortnight to superintend the erection of the others -

I remain,

Yours &c

G. J. Symons -

Member of Council of British Met. Society - Member of Scottish Met: Soc: &c —



Scottish Meteorological Society

10. St. Andrew Square

Edinburgh 4 July 1863.

Dear Sir

I laid your letter before the Meeting of Council held yesterday afternoon. They entered most heartily into the proposal judging it to be of the utmost practical importance. We have no pattern gauge just for the same reason that has induced you to institute this inquiry viz., the want of a well conducted series of experiments to determine the best gauge and its proper height. Some of the Council have given very special attention to this matter

Fig.3 (this page and opposite page): Reply from Buchan to Symons saying he will be sending two types of gauge (from the Royal Meteorological Society archives).

And I am instructed to send you two rain gauges, – one used by Captain Thomas which provides against evaporation and the splashing out of the drops of rain, and is moreover of easy measurement, – the other by Mr. T. Stevenson C.E., the chief peculiarity of which is in the lip.

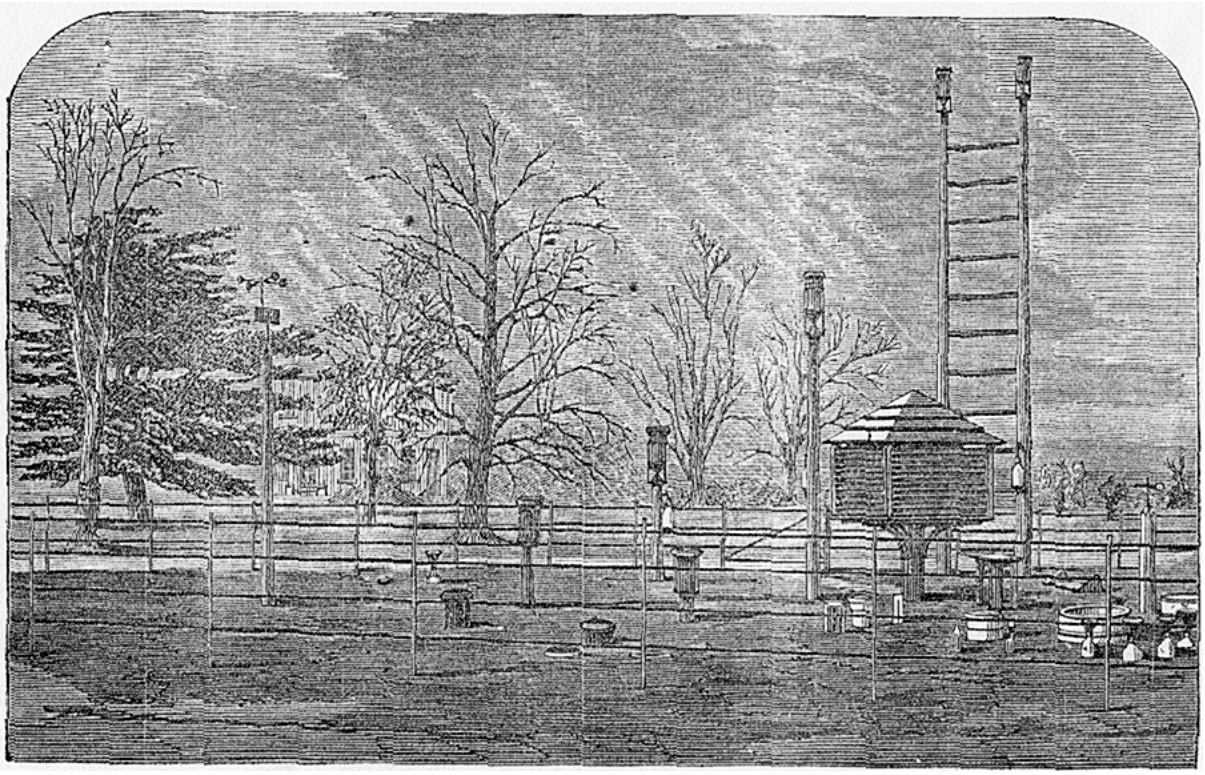
As they require to be made a day or two will elapse before they can be sent. Shall I send them to Major Ward direct instead of to yourself to save time?

I remain

Yours faithfully

Alexander Buchan

G. J. Symons Esq



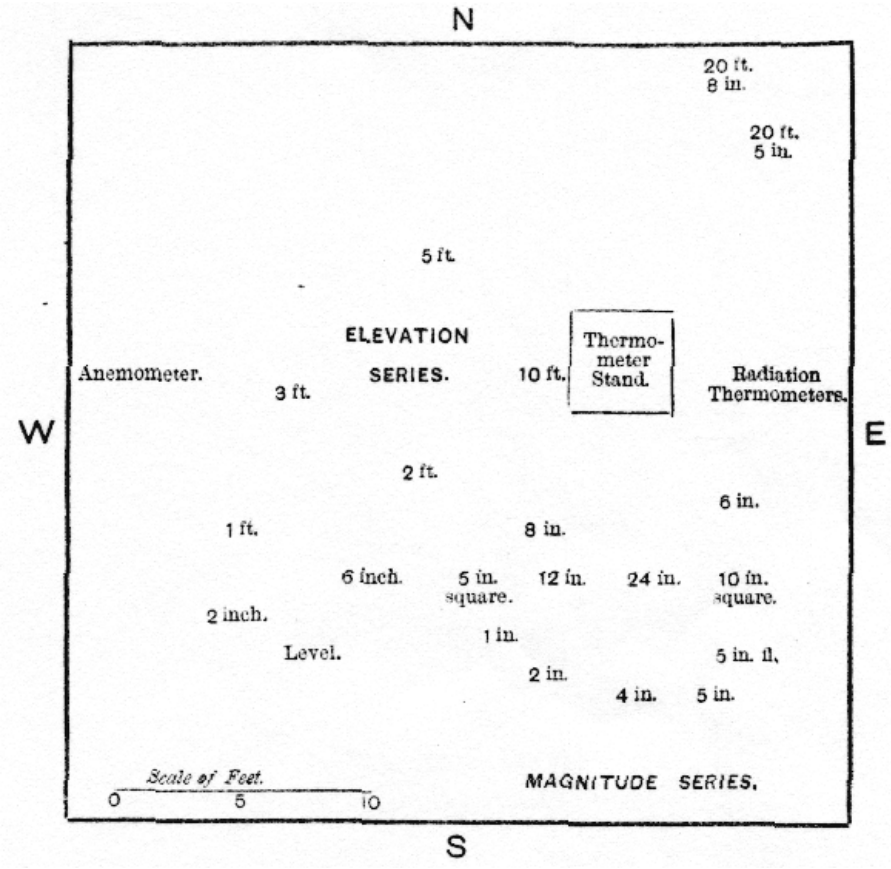


Fig.4
(above) Experimental gauges on the lawn of Michael Foster Ward at Calne, Wiltshire.
(below) Layout of gauges at Calne. (Both illustrations from *British Rainfall 1865*)

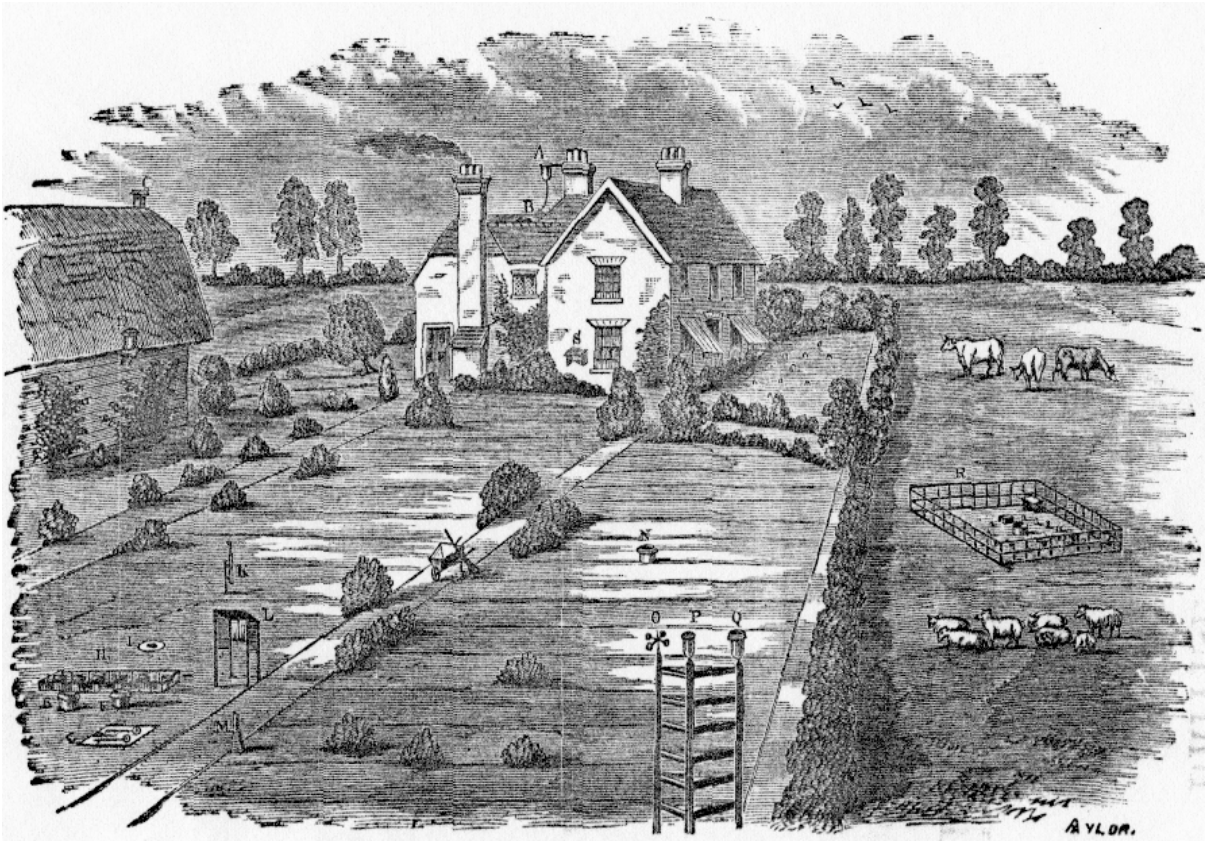


Fig.5
Experimental gauges in the garden of the Rev. C.H. Griffith at Stratfield Turgis, Hampshire, including those transferred from Calne. (from *British Rainfall 1868*)

for Fig.6, please turn over

RAINFALL AT CASTLE HOUSE, CALNE, WILTS.

Lat. 51° 27′ N. Long. 1° 59′ W. 250 ft. above Mean Sea Level.

FOR THE YEAR 1865.

ELEVATION SERIES. Diameter of Gauges, 8 inches.

Height above ground	Level.	2 in.	6 in.	1 ft.	2 ft.	3 ft.	5 ft.	10 ft.	20 ft.	5 inch. 20 ft.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January.....	3·893	3·863	3·581	3·517	3·163	3·225	3·203	3·062	3·159	3·134
February ...	3·482	3·528	3·019	2·933	2·849	2·826	2·806	2·634	2·679	2·546
March	1·007	·973	·912	·897	·868	·873	·851	·830	·842	·808
April	·782	·763	·736	·729	·720	·723	·706	·706	·693	·658
May	2·387	2·325	2·272	2·277	2·275	2·271	2·222	2·187	2·178	2·095
June	1·577	1·569	1·563	1·563	1·565	1·560	1·540	1·538	1·519	1·458
July	2·993	2·977	2·921	2·897	2·901	2·904	2·879	2·827?	2·722	2·780
August	4·280	4·240	4·211	4·203	4·203	4·223	4·176	4·147	4·082	3·974
September...	·128	·128	·120	·128	·138	·152	·143	·151	·144	·106
October.....	5·601	5·577	5·536	5·525	5·503	5·495	5·420	5·425	5·416	5·249
November...	3·454	3·402	3·327	3·279	3·207	3·221	3·139	3·097	3·094	3·026
December ...	2·705	2·626	2·557	2·478	2·413	2·404	2·364	2·301	2·351	2·257
Totals	32·289	31·971	30·755	30·426	29·805	29·877	29·449	28·905?	28·879	28·091

MAGNITUDE SERIES. Gauges 1 foot above the ground.

Diameter.	1 in.	2 in.	4 in.	5 in.	5 in. flange.	6 in.	8 in.	12 in.	24 in.	5 in. square.	10 in. square.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan.	3·113	3·257	3·435	3·614	3·591	3·481	3·558	3·416	3·400	3·462	3·397
Feb.	2·715	2·768	2·729	2·738	2·907	2·833	2·901	2·839	2·860	2·863	2·825
March	·741	·816	·891	·857	·893	·903	·936	·870	·862	·873	·857
April	·632	·688	·719	·735	·738	·740	·738	·714	·706	·700	·705
May	2·079	2·164	2·285	2·284	2·317	2·315	2·320	2·226	2·200	2·223	2·205
June	1·400	1·530	1·568	1·532	1·543	1·568	1·565	1·543	1·526	1·564	1·559
July	2·622	2·751	2·857	2·871	2·909	2·965	2·946	2·823	2·842	2·817	2·796
Aug.	3·948	3·997	4·124	4·173	4·185	4·229	4·239	4·112	4·115	4·080	4·069
Sept.	·055	·106	·122	·130	·125	·141	·153	·120	·115	·118	·113
Oct.	5·331	5·360	5·456	5·258	5·427	5·375	5·479	5·443	5·414	5·452	5·443
Nov.	3·073	3·087	3·165	3·209	3 174	3·316	3·134	3·213	3·195	3·153	3·186
Dec.	2·298	2·353	2·352	2·365	2·358	2·520	2·443	2·435	2·455	2·405	2·456
Totals	28·007	28·877	29·703	29·766	30·167	30·386	30·412	29·754	29·690	29·710	29·611

REMARKS.—*January.*—Intense frost on 29th ; min. 6°. Burst all the elevation gauges from "2 ft." upwards ; they were all frozen up from 24th to 29th, and melted on the latter day. The "level" and "2 in." were buried in the snow. *February 17th.*—Impossible to measure the three lowest gauges accurately, they being buried in the snow. *July 7th and 8th.*—Conducting pipe of 10 ft. gauge leaked ; the total measured was 2·577 in., and it is calculated that the loss was ·140 and ·110, which has been added to prevent a break in the series. *October.*—"Level" and "2 inches" very troublesome with leaves.—MICHAEL FOSTER WARD.

Fig.6: Annual rainfall for 1865 in the various experimental gauges at Calne, Wiltshire.
(from *British Rainfall 1865*)

continued from page 3

Likewise, in 1872, he explained lateness as owing to the skill, thought, patience and time needed in hunting out errors (1873). He put great store on accuracy, and demonstrated it by the shortness of the lists of errata (1871). He said 'I know that perfect accuracy is unattainable, but both inclination and duty compel me to use every effort in that direction' (1879). 'I shall continue to hold accuracy as the first essential; completeness and promptitude of publication shall follow' (1880). 'Few persons would devote the care which we do to the examination of the records submitted to us' (1881). He accepted 'an occasional growl on the part of some observer who does not value accuracy as highly as I do'. As for the few observers who get cross when their records are proved faulty, we 'lose them with equanimity'. But observers continued to cause frustration. In 1873, nearly 200 were still failing to send in their returns until three months after the close of the year (1874). In 1875, he explained that hundreds of hours would be saved if gauges were always in good repair, and observers never made mistakes, always wrote legibly, and sent their returns on time (1876).

Because of increasing comments from observers about lateness in publication, Symons was obliged to point out again, in 1877, that it was a consequence of delays by observers, not a sign of his dilatoriness (1878). In support of this claim, he said that following the usual circular sent in December, 500 had not replied by the end of February, 150 by the beginning of April, and still 80 by mid May. He gave a list – perhaps to name and shame! An element of despair creeps in for 1878 when he says: the 'yearly increasing severity of the ordeal of examination and comparison through which the returns have to pass delays publication' (1879). By 1880, he was pointing out that during the 20 years since the start of *British Rainfall* the 4 pages and 168 stations had grown to 260 pages and over 2100 stations, the exhaustive examination needed being finished in less than six months (1881). By 1882, 'none would credit the relief with which the editor sees the proof of the last sheet' (1882)! Fig. 7, published in 1909, shows the growth up to that year.

Text continued on page 14

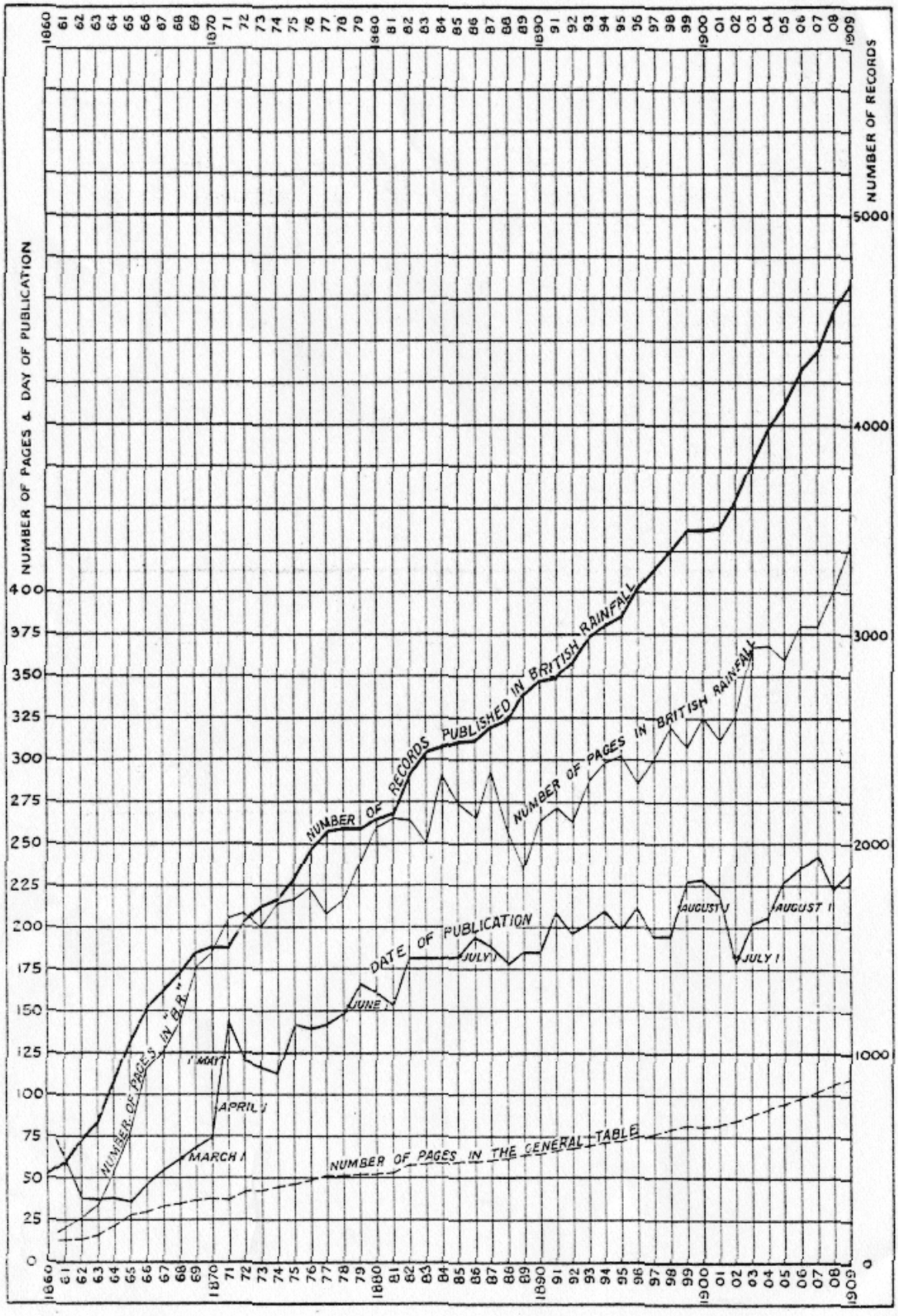
Fig.7 on pages 12 and 13

Year.	Date in following year of signing Preface.	Day of Year.	"British Rainfall." Total Pages.	General Table. Pages.	Total Records.
1860–61	Feb. 15	46	18	13	895*
1862	,, 7	38	26	14	588
3	,, 6	37	34	16	671
4	,, 7	38	54	22	865
5	,, 5	36	76	28	1060
6	,, 16	47	116	30	1214
7	,, 24	55	126	33	1292
8	March 1	61	144	35	1375
9	,, 10	69	176	37	1472
1870	,, 16	75	184	38	1509
1	May 24	144	206	37	1504
2	April 30	121	208	42	1630
3	,, 27	117	200	43	1696
4	,, 24	114	214	45	1727
5	May 22	142	216	46	1835
6	,, 19	140	224	49	1982
7	,, 22	142	208	51	2059
8	,, 28	148	216	51	2071
9	June 17	168	238	52	2069
1880	,, 10	162	260	52	2114
1	,, 2	153	266	53	2145
2	,, 30	181	264	58	2338
3	,, 30	181	250	59	2433
4	,, 29	181	290	59	2463
5	July 1	182	274	60	2486
6	,, 13	194	266	60	2488
7	,, 6	187	294	61	2555
8	June 25	177	256	62	2590
9	July 4	185	234	64	2708
1890	,, 4	185	264	65	2776
1	,, 28	209	272	67	2799
2	,, 14	196	264	68	2850
3	,, 21	202	288	70	2987
4	,, 29	210	298	72	3043
5	,, 18	199	302	73	3084
6	,, 30	212	286	75	3219
7	,, 14	195	300	77	3318
8	,, 14	195	320	80	3404
9	Aug. 16	228	308	82	3501
1900	,, 17	229	326	81	3493
1	,, 7	219	312	82	3506
2	June 27	178	326	85	3636
3	July 21	202	368	89	3829
4	,, 25	207	368	92	3982
5	Aug. 15	227	360	95	4096
6	,, 24	236	380	99	4259
7	,, 31	243	380	102	4345
8	,, 10	223	404	107	4538
9	,, 22	234	428	111	4681

* For 2 years. For 1866 there are 424 records, and for 1861 there are 471; "English Rainfall, 1860" published 168 records only.

Fig.7 (this page and opposite page): Growth. (from *British Rainfall 1909*)

PROGRESS OF BRITISH RAINFALL ORGANIZATION, 1860-1909.



NOTE.—*The heavy curve is to be read by the scale on the right hand side; the three light curves by the scale on the left hand side*

FINANCES

It is instructive to look in some detail at finance, for it throws light on what Symons was, and was not, able to do. Despite a perpetual shortage of funds to do all the work he considered necessary, Symons never published full accounts of costs of his work. Perhaps he felt they would make his organization look too official. Until 1863, he met the costs single-handed by himself, but in that year the British Association began making annual grants of about £50 specifically to provide additional gauges (1864). In the following year, about £100 were contributed by observers, and he began to make a charge of 2s 6d for testing a new gauge before despatch along with a printed certificate. He said: 'I am several hundred pounds the poorer for what I have done' (i.e., leaving paid employment), and 'it is not fair to expect me to continue such a sacrifice' (1865). This plea prompted more subscriptions so that, along with income from sales of publications, he was able to balance the costs of printing, stationery and postage. Additionally, in 1865, the Royal Society provided a once-only grant of £100 for a temporary assistant. In the same year, at the BA meeting, speaking about gauge inspections, Symons said 'if this Association will find the needful funds I will endeavour to double the number before I draw up the next annual report' (Symons 1866). This resembles an application for a research grant! From 1867, a list of observers sending £1 or more was included in *British Rainfall*, presumably to encourage others to make contributions. By then, it was clear there was support for the assertion, often made to him: 'that rainfall work of yours will never pay' (1867).

Finances continued to be a worry. In 1869, he said that the published data 'must still be regarded as a voluntary gift to the public by the observers, the British Association and the editor – who received less pecuniary profit than an ordinary clerk' (1870). The general public and engineer users, who paid 5s a copy for *British Rainfall*, would hardly be aware that the system 'could only be imperfectly perpetuated at an expenditure exceeding £12,000 a year'. This was presumably Symons's estimate of the cost of paying observers and of processing their data. He pointed out that 'the work is of national importance; should it not then be assisted with national funds?'; but 'funds adequate to provide a qualified assistant, or any remuneration for the editor, are not forthcoming' (1871). An appeal to observers in the following year raised only £20, insufficient to fund an assistant, but by 1872 they had increased enough to allow the employment of Herbert Sowerby Wallis. Indeed, by 1874, as a result of more observers sharing in expenses, he was able to say 'after ten or a dozen years of uphill work, I find myself with funds more than sufficient to meet the costs of assistants, printing, postage and travelling' (1875).

Perhaps it had been unwise to publicize this favourable balance, for the very next year the British Association ended its annual grant, which had averaged less than £100 and never exceeded £150 (1876). The reason was 'to force Government to undertake the provision of funds for the maintenance of the rainfall system, and in the teeth of my refusal to allow a system, created and developed during 15 of the best years of my life, to be buried in an obscure corner of some Government office'. It is clear that Symons felt strongly about maintaining the amateur status of his organization, perhaps reflecting his experience as a clerk under FitzRoy. He expected observers to make up the loss so that they would have the whole credit of supporting the system 'which hitherto has been widely reported to be maintained by the British Association'. Perhaps if he had published annual accounts his difficulties with funding would have been more widely understood. Although these developments threw extra expenditure on Symons it also freed him from presenting annual reports to the BA and allowed him greater scope in running the organization.

The cost of inspections, in particular, was a continual worry. It had been agreed with a committee of the BA that a permanent inspector should be funded, but by the engineers using the data. However, although proofs of a proposed circular making this point were prepared he did not get the hoped-for backing - only three members supporting the idea agreed to sign (1877). Nevertheless, 3000 copies were sent to BA members and associates in 1878 bringing their attention to the resolution that rainfall work 'should be taken up in a larger public spirit' (1879). There were only 69 replies, mostly to buy *British Rainfall*, and only 8 made contributions. Income continued to be stationary, with the 'organization crippled for want of funds'. Funding rested upon the observers, but 4/5 of the costs continued to be defrayed by 1/7 of the observers, and half the observers paid nothing at all (1880). In 1880, the Royal Society awarded a grant to work up averages for 1870-79, and the Meteorological Council paid £400 for 1866-1880 averages at nearly 400 stations for use in agriculture (1881). Lack of funds continued to plague Symons. In 1885, he commented that 'the distribution of money is one of the enigmas of this life; one sees tens, nay hundreds, of thousands of pounds utterly wasted as if thrown overboard in mid Atlantic – and on the other hand one sees work like this postponed, while life and strength fail, because the £2000 or so necessary to complete it is not forthcoming' (1884).

Despite all the problems, Symons was proud of the organization he had built up. In 1885, he claimed 'there is scarcely a spot in the British isles from which, were I suddenly dropped from a balloon, I should not be within walking distance of one of my correspondents' (1884). But as early as 1869 he was able to say 'we are now in rainfall matters far ahead of every nation in the world' (1870); and in the following year evidence was being received from all parts of the world of a rapid awakening to the practical utility of rainfall registration. Rules for British observers, developed by 1865 and printed in *British Rainfall 1868*, were being reprinted in both hemispheres, although England was 'the only country which does not defray the cost of the work, but leaves it entirely to private enterprise' (1871). In 1878 he was still able to claim 'the volunteer observers of this country keep up a system of rainfall registration which has no equal in the world, not even the United States' (1879).

HEALTH

Considering the size of the task that Symons had taken on it is not surprising that it affected his health. Already by the spring of 1864, when he was only 25, it had broken down so completely that for nine months there was comparative inaction, and it was doubtful if he would ever be able to stand the brunt of the work again (1865). However, he recovered, and indeed he married in 1866 and moved to the 'historic rainfall house', 62 Camden Square, in 1868 (Mill 1910). By then, he was working 16 hours a day during January and February – the time of year when the workload forbade any reply to correspondence (1869). After further illness in 1871, and signs of over-work (his duties as editor had become so onerous that nearly all his time was taken up with routine work) (1872), and it became clear that there was need to train a successor, he was able, at last, in the following year, to employ Sowerby Wallis, who soon became indispensable to Symons (Mill 1903). A small one-room office had been built for him in the garden, enlarged a few years later to two rooms and a fireproof recess fitted with slate shelves and iron doors for safe keeping of an abstract of all the records collected (Mill 1910). By 1882, there was also one permanent clerk as well as other occasional clerks (1883).

THE ORGANIZATION UNDER MILL

In February 1900, Symons was struck with paralysis and he died the following month, on 10 March, aged 61 (Burton 1993). The full workload then fell upon Sowerby Wallis, as Symons had desired, after they had worked together for nearly 30 years. He acquired all the records and books as well as a right to purchase the leasehold of 62 Camden Square (Mill 1910). However, he took on the work with grave misgivings that his own health would not long support it (Wallis 1903). There was clearly a need for someone else to step in, and in June 1900 Sowerby Wallis invited Hugh Robert Mill (Fig.8) to become joint Director of the organization (1901). Mill was a geographer but with a background in physical sciences (Pedgley 1994), and he had devoted much attention to rainfall, more especially in its relation to topography (1901). He joined the Organization in January 1901 (1919), at the age of 39, and produced a history of rainfall measurement from the start of Symons's work (Mill 1901). The post was unpaid, but it gave him a long-sought opportunity to extend study of topographic effects on rainfall. Sowerby Wallis continued to work with all his might until repeated warnings forced him to retire in 1903 (Mill 1903, 1910b), and Mill acquired the records, instruments and leasehold, with the intention of leaving them to the nation (Mill 1910 a, b). Becoming sole Director provided Mill with the opportunity 'to free the work of some of the cramping traditional methods that were retarding its growth … by division of labour, and more responsibility to assistants'; and he 'resolved to make scientific research the main aim of all branches of rainfall work, and the spirit of research give new life to … the Organization' (Mill 1951).

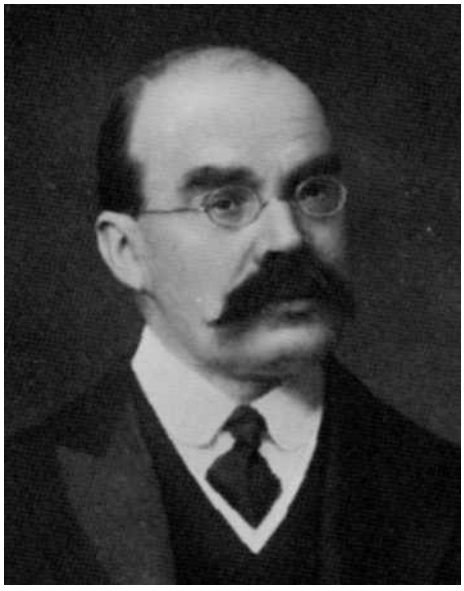


Fig.8: Hugh Robert Mill

Mill continued to use *British Rainfall* to discuss the distribution of rain on various time and space scales, as Symons had done, but with the aid of cartographic methods (Mill 1908). In 1903, he said 'it seems that the study of maps is the most promising field of rainfall research' (Mill 1903). Instead of seeking cycles from past data in order to predict the future, which he considered to be difficult and dangerous, he took 'the safe and unadventurous path of geographical distribution' (Mill 1908), employing patterns

of isohyets. These showed the contrast between individual thunderstorms and cyclones, and the different reflections of topography on monthly and annual totals, and on longer-term averages. Moreover, he demonstrated that maps could be used to detect accidental errors, to highlight areas with few records, and to estimate rainfall in data-sparse areas. 'It happens', he said, 'that rainfall is not only the most difficult of all the meteorological distributions to map accurately, it is also that one which is of the greatest practical importance' (Mill 1908). Moreover, there was a need for far more observations than with temperature or pressure because of great topographic influences.

Despite these valuable advances in the understanding of rainfall distribution through the use of maps, the routine work of the organization was leading Mill almost to despair by 1910 (Mill 1910a). One wonders if he had considered that he had made the right choice in becoming Director, judged by his comment when refusing to take on Leo Bonacina as an assistant in 1906 because much of the work was 'drudgery and the dullest routine' (Pike 2000). Indeed, on his retirement, Mill confessed: 'I overestimated my powers of coping with difficulties, the extent and nature of which were a progressive revelation' (1919).

The databank was still growing – by 1910 it amounted to 145,000 station-years, of which 10,000 were from before 1860, 95,000 from Symons's time, and 40,000 since (Mill 1910a). Few had met such a mass of data before. There was a need for better office accommodation and for more assistants so that he could be free to organize work, discuss records and undertake research. Striving to these ends had led to an increased deficit between income and expenditure that was met out of his own pocket (Mill 1910b), so that Mill had to spend more time on 'work of no value, except that it brings in money to enable the organization to be carried on' (Mill 1910a). There had been no offers of help from public bodies or individuals, and the Royal Society had not been approached because it was not sympathetic to earth sciences.

The problems previously encountered by Symons - maintaining the network, checking and publishing the data, editorship of two publications and swelling correspondence, all in the face of inadequate funding - were becoming too much for him. Already by 1903, he was lamenting that 'the number of promising pieces of research that are kept in abeyance because there is no money to pay for more assistance is a miserable thing to think of' (1904). He commented that some observers 'resent the suggestion that they could possibly make a mistake'. Concerning inspections, the chief difficulty was 'the utterly inadequate railway service in country districts. A few years ago, the bicycle supplied a quick and easy means of overcoming difficulty, but now cycling on the high roads of England scarcely differs in point of danger from walking on the railways'. He welcomed assistance from observers with 'modern means of locomotion', but two years later he noted that although there were probably several hundred motor cars among observers, only one had offered its use – enabling inspection of seven stations in a few hours (1906). 'This experience shows that it is no longer impossible to inspect all the rainfall stations in the course of a few years'.

TIME FOR A CHANGE

Although Mortyn de Carle Sowerby Salter, who had been taken on as an assistant by Symons in 1897, carried more and more of the burden of routine work – he became the chief of five assistants in 1907, joint editor in 1912, and Assistant Director in 1913 (Mill 1919) – it was too risky for an individual to carry such a heavy burden as Director (Mill 1910b). By 1910, Mill had concluded that the Organization could not go on that way much longer. There was a need for change, now that the 50th year of the organization had come. He set up the nucleus of an Endowment Fund, with £1,100 given or promised, to be overseen by nine Trustees, drawn from among the observers, with himself as Chairman. Mill said that the sole motive in establishing the Trustees was 'to assure the future of British Rainfall Organisation for all time as a purely scientific institution, putting to the utmost possible use the voluntary cooperation of the observers'[2].

The Trustees took over the property in 1910, and had the power 'to unite with any other body of kindred aims' if the need arose. It was thought that when the Fund had grown enough it might be reasonable to approach Government for a grant. The aim would be for the Organization to have greater financial stability and to be able to pay all its expenses, including a salary for the Director. However, observers were to be unpaid because 'the merit of a voluntary observer is not that he does the work cheaply, as compared with a paid one, but that he does it better'(Mill 1910a). Mill also hoped that a salary would enable him to discard much of the professional work that had been built up by

[2] Quotations without references are from correspondence in RMS archives

Symons, which was mainly to determine rainfall over gathering grounds for benefit of water engineers, and to provide evidence in courts of law or before Parliamentary Committees. He felt that such work involved the risk of subordinating science to financial considerations; and anyway it consumed a great deal of time.

Introduction of the Endowment Fund led to a short-lived jump in income, but it was not as great as hoped for (Mill 1919). Moreover, Mill's sight failed in 1912. He had to give up rainfall work, saying 'I must get out of the whole thing as soon as possible. It has been a thankless job altogether and there will be some relief in giving it up'. After consulting Trustees (through letters written by his wife, Frances), he proposed in May 1913 three alternative schemes for the future of the Organization: (1) merging with the Meteorological Office, retaining Trustees as custodians of the records and Endowment Fund, like the Gassiot Trust responsible for Kew Observatory; (2) continuing as before, but finding a new Director, carrying on unpaid and taking responsibility for any deficit; (3) appointing two co-Directors, one to pay special attention to editorial and research work, the other to correspondence and collection of data. But he had reservations. With the first alternative, he said 'a great drawback appears to be that official control would endanger the flexibility of a voluntary system which has been the mainstay of the success of the Organization'. As to the second scheme, he proposed 'Salter to act as interim co-Director until a new Director had acquainted himself with details of the work, but there may be difficulty in finding a person of experience and reputation who is willing'. For the last scheme, he proposed appointing Salter and Robert Mossman, the latter being well-known as a meteorologist on Ben Nevis and in the Antarctic, and soon to be looking for work on his return to Britain after being Editor of Publications in the Oficina Meteorologica Argentina. The third scheme was adopted, with Mossman joining principally as editor of publications until he left in 1917.

Mill realised 'that the system was only possible at the cost of the health of the Director and staff and that it must be changed' (Mill 1919). Indeed, an application for funding was made to Government in 1913 but it was not accepted, as a result of differences of opinion between Departments and the Treasury. After a long break, including six months in New Zealand, Mill's health was so far restored that he was able to return to work in 1913, making arrangements for retiring (1913). But they had to be postponed with the outbreak of war. Discussions in 1915 and 1916 with Napier Shaw, of the Meteorological Office, led to progress in plans for the first scheme. Association with meteorological services set up by the Admiralty and the Air Board brought the Organization in touch with other Government agencies, leading Mill to think that closer coordination would be a natural development (1919). But the war years brought problems. Because staff joined the army, Mill resolved to keep going despite his ill health, using the help of his wife and Salter. He lived at his home in Surrey but spent two or three nights a week at Camden Square. Introduction of millimetres by the Met Office (in 1915) led to a need for conversion of readings and to renewed difficulties in defining a rainy day, and introduction of summer time (in 1916) somewhat marred the uniformity of observing times. Stringencies led to postponement of both studies and office enlargement. Even so, the decrease in number of records was small, reflecting, Mill claimed, the value of a voluntary system (Mill 1919).

In the closing weeks of the war, Mill resumed discussion of merger with the Director of the Meteorological Office, Henry Lyons, who agreed, along with the Meteorological Committee. At the annual meeting of the Trustees on 23 July 1919, an agreement with the Director was signed to finalize a merger, with safeguards on continuity of publications, encouragement of voluntary observers, maintenance of services to the public, and security of staff interests (1913, 1920). In the previous year, Mill had suffered a serious accident that prevented him from retaining 'any position involving either hard work or heavy responsibility' (1919), and he retired at the hand-over, leaving the organization as a department of the Met Office, with Salter as Superintendent (1920).

So the BRO ceased to exist as a separate entity, but its 5,000 observers carried on. The last of those reporting since 1860 died as late as 1928.

CONCLUSIONS

Symons's great achievement was to develop a network of gauges with a general uniformity of measurement and recording. It was a model for other countries, although depending almost entirely on unpaid volunteers. As Mill said later (Mill 1938): 'Symons never grasped the value of mathematics or the importance of theoretical reasoning. He was essentially a collector of facts. A shrewd common sense controlled his underlying fire of enthusiasm, so enabling him to devise rigidly thorough methods of computation, checking and book-keeping. He was able to keep personal contact with his growing army of observers and in so doing made friends with all sorts – from the most eminent men of science to the merest dabblers in harmless hobbies'.

But Symons from the start had underestimated the task he had undertaken. He had to overcome many problems, not least the ever-increasing work-load and the constraints imposed by perpetually insufficient funds. Despite repeated appeals to observers and others, funds were never sufficient to accomplish many tasks without over-working; and worthy projects were delayed, sometimes indefinitely. Indeed, Symons repeatedly met the Organization's deficits out of his profession fees. It is surprising that users, particularly water engineers, were unwilling to provide adequate funding.

This essentially gentlemanly pastime of data gathering was transformed by Mill into an increasingly exact science, largely through the introduction of mapping, from which much was learnt about the distribution of rain on various time and space scales. Again, however, it was a case of taking on a task greater than imagined, so it was wise to put the Organization in the hands of Trustees, and to try to avoid the need for support from the Director's professional fees. Continual problems with finances and ill health, worsened by the stresses of the war years, made it necessary, in 1919 after 60 years, to merge the organization with the Meteorological Office.

To finish, it is worth noting that the title 'British Rainfall Organization' never seems to have been used by Symons. He first refers to his 'system' of collecting records, with himself as the 'centre' (1864), and from the 1870s he uses 'organization' with a small 'o'. Capital 'O' does not appear until the 1890s. 'British Rainfall Organization' was used by Wallis in 1900 and by Mill in 1903, and it was formalised by the latter in 1910, in the deed when the organization was handed over to the Trustees.

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