1907.

NEW ZEALAND.

RAIN-MAKING EXPERIMENTS AT OAMARU

(REPORT OF METEOROLOGICAL OBSERVER ON).

Return to an Order of the House of Representatives dated the 13th November, 1907.

Ordered—"That there be laid before this House the report of the Meteorological Observer who conducted the recent rain-making experiments at Oamaru."—(Mr. MASSEY.)

REPORT.

SIR,—

In accordance with instructions, I have the honour to make this report upon the dry period, 1906–7, and the rain-making experiments at Oamaru, August, 1907.

D. C. BATES.

The Secretary, Marine Department, Wellington.

The district of north Otago, often called, after its chief town, the Oamaru district, is sheltered on the west, north, and south by mountainous ranges, which condense and precipitate on their windward slopes much of the moisture borne by the winds from these directions, and it must therefore depend chiefly on easterly weather for its rains. The north-easterly and south-easterly winds which accompany cyclonic disturbances, and are usually laden with water-vapour, sweep up the Kakanui and Waitaki valleys, causing the most abundant rains to fall over the district. In some seasons, however, these atmospheric movements do not extend their influences so far south, and then, while the North Island gets more than the usual amount of rain, those parts of the South Island depending upon them are liable to experience droughts. A prolonged dry period of an unusually severe character for any part of New Zealand extended over the Oamaru district during the years 1889, 1890, and 1891. The years 1897 and 1898 were also very dry, and the last period of deficient rainfall, from January, 1906, to August, 1907, was 45·7 per cent. below the sum of the average monthly rainfalls for the eighteen months included.

Rainfall-observations for the Meteorological Office have been kept at Windsor Park, Oamaru, since 1892 by Messrs E. and W. Menlove; also at Kauroo Hill, near Maheno, by Messrs. R. A. Chaffey, C. de V. Teschemaker, and A. French, from the 1st January, 1890. While in Oamaru I learned that much older records had been kept by the late T. W. Parker, Esq., Resident Magistrate; and these, extending from 1866 to 1893, were presented to the Meteorological Office by Mr. H. Edwards, who had continued Mr. Parker's work for a few years. Another valuable record, with many interesting details of the effects of the weather upon pastoral and agricultural affairs, was also lent to us by Mr. James McPherson, of Totara Station. This record extended from 1888 to the present.

The annual rainfalls for Oamaru are as follows:—

	In.		In.		In.		In.		In.
1867 ...	23·58	1875 ...	23·39	1883 ...	28·23	1891 ...	16·60	1899 ...	27·41
1868 ...	25·73	1876 ...	17·20	1884 ...	26·82	1892 ...	23·03	1900 ...	20·36
1869 ...	18·33	1877 ...	26·75	1885 ...	16·81	1893 ...	20·04	1901 ...	18·79
1870 ...	32·82	1878 ...	20·26	1886 ...	26·36	1894 ...	23·71	1902 ...	29·56
1871 ...	16·32	1879 ...	25·56	1887 ...	26·28	1895 ...	24·26	1903 ...	18·37
1872 ...	19·93	1880 ...	20·37	1888 ...	29·10	1896 ...	23·75	1904 ...	19·62
1873 ...	28·00	1881 ...	13·47	1889 ...	14·33	1897 ...	14·12	1905 ...	23·26
1874 ...	21·79	1882 ...	25·67	1890 ...	14·15	1898 ...	15·96	1906 ...	14·81

which yield 21·87 in. as the average annual rainfall for the period of forty years, and show a maximum of 32·82 in., in 1870, and the minimum, 13·47 in., in 1881.

The continuous and unbroken record for this period gives the following monthly averages, stated in inches:—

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
2·24	1·88	1·32	1·73	1·62	1·78	1·67	1·47	1·89	1·55	1·98	2·30

The average number of days with rain (0·01 in. or over) from the Windsor Park records are—

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
12	11·6	9·7	9	8	7·4	8	8	9	10	11	13

showing that the expectancy of rain is greater in summer than in winter.

The Windsor Park records of the recent dry period are as follows :—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906	...	1·25	0·52	1·16	0·73	1·42	0·59	0·59	1·46	0·62	0·95	2·46
1907	0·43	1·39	1·41	0·58	0·71	0·24	0·56	...	...	...	...	...

Only one month (December, 1906) with total rainfall above the average, and that by merely sixteen points.

The days with rain (0·005 in. or over) during this time were—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906	...	13	10	5	4	5	6	4	8	7	5	10
1907	5	9	11	7	2	4	7	...	...	...	...	...

As might be expected in that undulating country, the records from Kauroo Hill Station differ from the above very considerably at times. The averages from the seventeen years' records at Kauroo Hill are—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Inches	2·61	2·19	1·68	1·24	0·94	1·18	1·23	0·69	1·97	1·42	2·08	2·31
Days	9·8	7·8	6·6	6·3	4·5	4·4	5	4·6	8·2	8·24	9·4	10·9

And the quantity during the eighteen-months dry period,—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906	...	1·42	0·49	0·99	0·71	1·19	0·48	0·50	2·29	0·45	0·98	1·27
1907	0·46	1·95	1·63	0·78	0·80	0·23	0·50	...	...	...	...	...

which shows the total fall for this period as 39·1 per cent. below the average.

The results of this small rainfall, though by no means comparable with the effects of drought I have experienced in the heart of Australia, were more severe than I had imagined possible in this country. The fields were very bare, especially new pastures, which had been sown with English grasses in the past few years. The fields which were being ploughed showed a dry subsoil which had apparently not been moistened by a good rain for a long time. I was driven over a great part of the district, and only saw one small field of fair-sized turnips, while on an average between fifty and sixty truck-loads of these roots were being brought from Southland every day for northern and central Otago. The stacks of straw which the farmers have at last learned to save at harvest-time were commanding high prices, and in addition quite 9,300 tons of fodder had to be imported by the settlers to keep their starving stock alive. This food was carried from the south free for the purchasers, who were thus relieved of a great stress and encouraged to save their stock. Much of the stock had to be removed elsewhere for pasture and sold off or killed, and nearly all left were in very poor condition; but, owing considerably to the timely and generous assistance of the Government, very few were seen dead in the fields.

The acreage and yields for the Waitaki agricultural district for the past ten seasons, as published by the Agricultural Department, show a lower yield for wheat for 1906–7 than any since 1897–98, while the yield per acre in oats was the lowest recorded.

	1897–98.	1898–99.	1899–1900.	1900–1.	1901–2.	1902–3.	1903–4.	1904–5.	1905–6.	1906–7.
				Wheat.						
Acres ...	37,955	44,423	29,936	22,347	18,558	21,594	27,112	28,808	27,927	24,925
Average yield (bushels)	13·2	36·6	36·4	31·4	22	39	39	40	32	20
				Oats.						
Acres ...	21,080	19,268	21,216	24,696	23,094	27,075	22,376	18,567	20,656	19,688
Average yield (bushels)	21·7	43·3	48·2	48·6	38	55	42	47	41	20

To sum up this aspect of affairs, I would like to quote a concise statement of the Oamaru correspondent of the *Evening Post* (12th August, 1907), who estimated that the eighteen months' drought at Oamaru had cost the district not far short of a million sterling. "On the last grain-harvest, as compared with previous averages, there was a loss of £200,000, and loss on the decreased output of butter ran into nearly another £50,000. It has been computed that about 75 per cent. of the cattle and 50 per cent. of the sheep that were in the district twelve months ago have been potted, or exported to more favoured districts."

Under such trying circumstances it was tantalizing to the farmers to hear of good rains falling in other parts of the country and to see the clouds at such times hang over the mountains, or watch them passing high up in the air away to the ocean. Such disappointment as they so frequently experienced led many inhabitants of the district to favourably regard the project of experimenting for the purpose of inducing the clouds at some favourable opportunity to yield their moisture. Several of the most progressive, enlightened, and experienced farmers and business people who have the best interests of the community at heart—men who support local affairs such as pastoral and agricultural shows, and who have introduced and experimented on new seeds and strains of stock in the district—promoted the experiments, arguing that it might be possible for a small outlay to secure results of infinite value. The promoters were men who commanded the respect and sympathy of the public, and a large sum of money was readily subscribed. This amount, through the efforts of Mr. J. Macpherson, M.H.R., was also supplemented by the Govern-

ment, and given its greatest power of purchase through the supply of explosives at cost-price from the Defence Department of New Zealand. I was ordered to proceed to Oamaru simply to watch and report upon the proposed experiments.

On my arrival I was met by the members of the committee who had the matter in hand, and, while disclaiming all responsibility for the experiments, I discussed the project freely with them, finding their idea was to seek favourable opportunities to cause the passing clouds to precipitate. They desired me especially to advise them as to these, and to indicate times when the air would be saturated with moisture, or, to adopt a phrase of the late meteorologist, Rev. Clement Ley, such a state of "unstable equilibrium" would prevail that it might possibly be disturbed, and the "water-dust" of the clouds be made to coalesce, and precipitation ensue. They did not hold that they were able to produce rain at any time, but firmly believed that they could only operate successfully in a cloudy and saturated atmosphere. Though I could not share their very sanguine hopes for such results as desired, yet I tried my best to meet their views, and to the utmost of my abilities heartily co-operated with the committee. I only wish that more of the committee could have witnessed the experiments, and have come, with the Press, to definite conclusions.

Rain was badly wanted, and at first the committee were too much in earnest both in their faith and efforts to regard the experiments in the light of pure science. As is well known, rainfall is one of the most uncertain elements in meteorological prognostication for such a district, and the "probability of rain" with certain disturbances rarely amounts to absolute certainty; but events were moving in such a manner that I could forecast periods of saturation in the near future. The times thought most favourable for rain, fortunately for the district, coincided very nearly with such widespread and abundant rainfalls as had not occurred for years, and on this account, unfortunately, my task of giving conclusive evidence as to cause and effect in the experiments was rendered more difficult. While admitting this, I desire most clearly to maintain that in no case was I able to trace such effect or success in rain-making, due to the explosions, as some local residents at the time claimed with considerable assurance. I have, moreover, read the records of similar experiments made on the 17th November, 1891, on Raki's Table, and referred to with even greater confidence. Rain fell at that time, but I find from our records that the fall was heavy and general between Cape Campbell and Dunedin. The reports of the effects of the explosions on the clouds, and on the barometer and hygrometer, are interesting, but by no means of a convincing character. For example, before one experiment "the barometer stood at 28·95 in., and five minutes after the explosion it fell to 28·92 in., ten minutes afterwards to 27·75 in., and," it is added, "was apparently continuing downwards when we left the Table." A fall of the barometer, in the open air, of $1\frac{1}{4}$ in. at least in fifteen minutes would probably show a world's record for all time, and one need hardly discuss the possible effects of such a drop: we might almost speak of it as a "vacuum" in the atmosphere. The chief claim for further experiments was based on this reported change. In every case where we watched reliable barometers near the explosions only a slight quiver was noticed at the moment of detonation, while the instruments went on steadily rising or falling as at other places.

The sites chosen for the experiments were lonely hills which commanded views of the whole district, and on that account had all been used as trigonometrical stations for the survey of the district. Raki's Table, the chief site, is a flat-topped hill 1,059 ft. above sea-level and fourteen miles inland, as the crow flies, north north-west from Oamaru. Round Hill, on the Totara Estate, is a remarkable cone with an elevation of 501 ft. above mean sea-level, and about six miles south-west from Oamaru. Dalgety's Hill, near Duntroon, is in the Waitaki watershed, and is about 811 ft. above mean sea-level, and fifteen miles north-west from Oamaru. The positions had been carefully chosen by the committee, and both the situations and elevations were admirable for the purpose. The aim was to work with the wind rather than against it, and it was hoped that we should be able to trace the effects of the explosions on the clouds over the area affected.

The First Series of Experiments.

On the afternoon of the 16th August the skies were dull—strato-cumulus clouds hung round the hills, and were scattered overhead. It appeared even to be raining at a distance away to the south, but the weather was quite fine for us on the way to Arnmore Station, near Raki's Table. We arrived at Mr. P. S. Shand's residence about sunset, and, although heavy misty clouds were falling on the Table, and residents thought rain imminent, there did not seem to be sufficient density about the clouds. The air showed a relative humidity of 92 per cent. of saturation, and only needed a fall of the thermometer of 2·4° to reach the dew-point. The cool of evening was approaching, and the wind, though light, was in the rainy quarter, the south-east. On the whole the conditions were regarded as fairly favourable. It was regarded chiefly as a trial of the bombs, and for working the men together under Corporal Meikle, prior to using the other stations.

The explosives used on this occasion were,—

(1) 5.15 p.m.: $17\frac{1}{2}$ lb. dynamite, $12\frac{1}{2}$ lb. powder; in keg.
(2) 5.30 p.m.: $17\frac{1}{2}$ lb. " , $12\frac{1}{2}$ lb. " ; "
(3) 5.45 p.m.; 40 lb. " , 25 lb. " ; in case.

These behaved differently. The first shot gave off a good report, and the smoke rose and drifted gently away to the north-west. The second did not explode well, for the powder seemed to burn in the air without detonation. The third shot, which had a weight of 65 lb., gave a great concussion to the air, and vibrations were felt over a wide area.

As far, however, as we could see there were no other than natural changes going on in the atmosphere. We left for Oamaru at 10 p.m., and the evening was quite fine. In the *Oamaru Mail* however, next day, the following paragraph appeared: "As showing that the explosions which took place last evening, although modest compared with what are to follow, were not

altogether unaccompanied by that practical result which farmers look for as the outcome of the experiments, it may be mentioned that Mr. George White and several other farmers were conversing on the probability of rain descending from a certain cloud which appeared to be hanging on Tokaraki, if unsettled by concussion, at the times the bombs were, although unknown to Mr. White and his friends, being tested on Raki's Table; and as they conversed they were surprised to hear the boom of the explosions, and immediately afterwards a shower of rain, lasting for half an hour, fell in the vicinity of Hilderthorpe. This may have been a coincidence, but as a coincidence it is remarkable."

As a result of this trial it was decided that the explosions should be given more resistance, fired off rocks, and at the next opportunity detonated almost simultaneously from the other stations. A small cannon with a few pounds of common powder would, in my opinion, have given greater vibrations of sound, and a shorter and sharper shock, in place of the dull and heavy report of these powerful explosions. I would not advocate their purchase, but I believe that the cannons used for this purpose are of the blunderbuss type; and, though numbers of these have been employed together, and some, "sending vortex rings" up to great heights, have had great claims made for them by their vendors, yet they are by no means recommended by those meteorological experts who have investigated their claims. They have mostly been used for the prevention of hail—to drive it away, or to cause the clouds to precipitate rain before the formation of hail. Theoretically one would imagine the heat caused by these explosions would tend to dissipate the clouds and the friction of the vortex rings especially to create but slight disturbances in the air, which would not induce precipitation, but naturally rather the reverse.

The Second Series of Experiments.

On Sunday, the 18th August, the coming of what appeared to be merely a westerly area of low pressure developed into a cyclone, which promised greater rain and sooner than would have come from the ordinary type, which would have culminated between the 19th and 20th. There was a drizzle falling on Sunday morning at Oamaru at 4 a.m., and at 9 a.m. 0·04 in. was recorded. The day was dull and threatening, and rain set in again at night—0·40 in. was recorded in the morning. At Totara Station, in the Kakanui Basin, Mr. McPherson recorded 0·73 in. The rain was mostly confined to the sea-coast while the barometer was falling: it was 29·99 in. on Saturday, and 29·47 in. on Monday at 9 a.m. I expected much more rain would come with the rise of the barometer and the shift of the wind to the south, but as yet hardly any rain had fallen inland. The rain held off, but the skies continued cloudy. The committee decided to experiment at Raki's Table when they heard no rain had fallen there. We left Oamaru at 12.30 p.m. on the 19th, and as we got out into the country found the roads dry, but bad weather was evidently working inland, and there was a very light drizzle falling as we arrived at Arnmore about 1·45 p.m. Corporal Meikle was then making an explosion which had apparently no effect, though the hygrometer showed that the air was saturated with moisture. Earlier, at 12.30, another shot had been fired, and artillerymen and others affirmed that it drew rain in fifteen minutes, and brought the clouds down on the Table insomuch that the view of the surrounding country was obscured. We missed the artillerymen on the road, but in company with Mr. Shand I at once visited the top of the Table. We found the wind strong and gusty from the south-east. The sky was dark and lowering, and two showers fell before the artillerists returned. Raki's Table was then enveloped in a thick Scotch mist, spitting with rain, but heavy showers soon set in, and continued to fall at intervals. I regarded these as perfectly natural, and was confirmed in my opinion when I learned that the rain-squalls had the same intermittent character long before they reached us. It could hardly be maintained that the explosions would have so marked an effect as this on the rain fourteen miles away, and against the sweep of a wind averaging at the Table about twenty-five miles an hour. While I saw no perceptible difference made in the showers sweeping down upon us and progressing over the country, others were quite as decided in their opinions that the rain thickened heavily after each successive shot.

The barometer continued to rise, and those who watched the instrument agreed that there was no fall after the several shots. The weather continued very raw and wet, but the hygrometer showed the same dew-point as before.

The explosions were as follows:—

	Time.	Gun-cotton, lb.	Dynamite, lb.	Gunpowder, lb.	Weight of Charge, lb.	How made up.
(4)	12.30 p.m.	...	50	...	50	In 5-gallon oil-drum.
(5)	1.45 p.m.	...	...	50	50	"
(6)	3.56 p.m.	...	50	...	50	"
(7)	4.5 p.m.	...	65	...	65	In case.
(8)	4.17 p.m.	50	60	...	110	"
(9)	4.30 p.m.	50	100	...	150	"
	...	——	——	——	——	
		100	325	50	475	

Rain fell on the 19th and 20th over a very wide area in the South Island, and the falls at this time recorded by the observers of the Meteorological Office are as follows (inches):—

	Windsor Park.	Otekaike.	Livingstone.	Arnmore.	Kurow.	Waimate.	Oamaru.	Totara.	Kauroo Hill.
18th ...	0·16	...	...	0·03	...	...	0·40	0·73	...
19th ...	0 53	1·15	0·70	0·52	1·17	0·03	0·36	0·40	0·10
20th ...	...	0·15	0·53	0·09	0·12	0·50	...	0·06	0·70

The falls were very different at the various places, but such wide-spread and heavy rains could hardly be attributed to artificial means.

The Third Series of Experiments.

On the 22nd everything was ready for a trial on a larger scale. There was a cloudy sky, a rapidly falling barometer, following a frosty night, and local indications fell in with the wider aspect of affairs—rain before long.

The explosions were as follows :—

Time.	Gun-cotton, lb.	Dynamite, lb.	Gunpowder, lb.	Weight of Charge, lb.	How made up.
		Raki's Table.			
(10) 3.30 p.m.	...	100	...	100	In 10-gallon oil-drum.
(11) 3.40 p.m.	...	100	...	100	"
(12) 3.50 p.m.	50	150	...	200	"
(13) 6 p.m.	...	150	50	200	In case and keg.
		At Dalgety's Hill, Duntroon.			
(14) 3.30 p.m.	33	67	...	100	In 10-gallon oil-drum.
(15) 3.39 p.m.	33	67	...	100	"
(16) 3.49 p.m.	33	67	...	100	"
		At Round Hill, Totara.			
(17) 3.30 p.m.	25	25	...	50	In gun-cotton case.
(18) 3.40 p.m.	25	25	...	50	"
(19) 3.50 p.m.	25	25	...	50	"
(20) 3.55 p.m.	25	25	...	50	"

The charges were primed with dry gun-cotton and fired by dynamite detonator attached to a slow-burning fuse. In nearly all cases complete detonation took place, but it would have been much more satisfactory had each case of explosives been connected and the explosions made by electric current. In one instance it was noticed that three cases of dynamite exploded—one upwards and two others sideways, and not quite simultaneously—so that it appeared as if a single cap was not sufficient for complete detonation. Thus, however, we had both effects—explosions ballistic in character and detonations shattering.

From Raki's Table I watched the experiments at Dalgety's Hill, five miles and a quarter to the north-east, and those at Round Hill, nine miles and a half to the south-east. The skies were again very heavy—stratus clouds were between 800 ft. and 1,000 ft. above the Table most of the time, and hung low, but well defined underneath all round, excepting in one bright patch away to the south-west, where there was an arch over a mountain range. The wind at first was a light north-west and later shifted to the south-west without much change in the clouds, except perhaps they lowered as the evening advanced. This time, so far as we could see everywhere, there was no apparent change made by the explosions, and the smoke drifted upwards, and then gently away on the breeze. The barometer falling slowly all the time, the high relative humidity approached saturation at sundown; but, though the mist looked heavy all about, the rain was not quite ready, and explosions did not seem to expedite matters. Up to that time the experiments certainly were ineffective in the precipitation of rain. It did, however, come some hours afterwards, and some people in the locality might possibly attribute this result to the experiments, but those who were actual eye-witnesses on those lonely heights could, I imagine, hardly entertain such ideas. Those efforts were puny in comparison with the mighty forces which were at that moment developing independently over thousands of square miles in a cyclone similar to, but more intense than, the one which had brought rain only a few days before. It did indeed seem to be following in its tracks.

Rain commenced at Oamaru about midnight on a north-east wind, and was general throughout the district of north Otago, and, though central Otago did not benefit as much as was expected, yet so far as the Oamaru district was concerned the dry period was at an end, and there was great rejoicing everywhere.

The rainfalls of the locality, placed, as usual, to the previous day to that on which they are read at 9 a.m., are as follows :—

	Windsor Park.	Otekaike.	Livingstone.	Arnmore.	Kurow.	Waimate.	Oamaru.	Totara.	Kauroo Hill.
22nd ...	0·47	0·19	0·41	0·35	0·23	0·43	0·39	0·30	0·31
23rd ...	1·44	0·88	1·12	1·65	0·44	2·10	2·02	2·24	1·88

General Observations.

Besides the valuable statistical information acquired by me in Oamaru, an increased interest in meteorology itself has, I trust, been a direct outcome of these experiments in the district. Though science may not yet be able to forecast drought-periods, yet they may be promptly recognised, and then, with the aid of experience to be gained from other lands, combated on scientific lines, and by turning adverse circumstances to good account, success may be wrested even from apparent failure. These costly efforts in rain-making are regarded at present as misguided and vain by all scientific meteorologists, while to their chagrin really valuable work is often neglected for want of public interest. On this visit I have established four new third-class stations for the observation of rainfall in the Oamaru district, and I earnestly recommend the establishment of one second-class station at Oamaru.

The whole matter with regard to rain-making experiments resolves itself into the question, Can man according to the dictates of his needs either directly or indirectly produce rain upon the earth? Professional rain-makers in civilised countries have made repeated efforts, and by various

methods, to cause rain, but from America, Europe, India, and Australia come records of their failure, and only personal experience seems to satisfy every nation and each generation of their futility.

The chief arguments used in favour of the experiments, besides those alluded to before, were that rain generally followed great battles, explosions, and disturbances of the air as by reverberations of thunder—nay, even the passage of a train through a moisture-laden atmosphere. I was informed that in parts of Wales where slate-quarrying is carried on it usually rains every day while blasting is done, but that the Sundays will be fine because operations cease. Reviews of troops and sham fights have been followed by rain, and this has been attributed to the firing. The coincidence of rain with reviews has often been unduly impressed upon the minds of people by its effect on smart dresses and uniforms, for the display of which, and for convenience in marching, cumbersome overcoats have been discarded; and this fact discounts such evidence. Professor T. Russell, in his "Meteorology," says, "It has been supposed that the concussion of artillery-fire in battles produces rain, and that great battles are followed by heavy rain. There is no reason why this should be so. No physical relation has ever been traced between concussion of air and formation of water-drops. The belief is very ancient that battles are followed by rain. In Plutarch's Lives it is related that after the battle of Marsalia in France, a great rainfall followed, and it is mentioned as being a well-known fact that all great battles are followed by heavy rain, This was certainly a case when rain was not due to artillery-fire." Rain, if coincident with battles. has the most marked effects on these stupendous operations of human activity.

Globules of water are formed on particles of dust, and the vapour-atoms of gases, or ions; but there is no reason to suppose that these droplets are hollow vesicles which could be burst by explosions. Condensation is induced in a supersaturated atmosphere by the presence of dust, the fumes of ammonia, phosphorus, sulphur, &c., as these particles form nuclei for the minute spherical drops of water. The passage of a train might bring such in smoke, but the results would only be insignificant. Fog and smoke may hang over London, but the rain is no greater than in the country. Thunder and lightning are, again, effects of electrical disturbance, which is also a result of the usual cause of precipitation—viz., the cooling of a vapour-laden atmosphere. A thunderstorm is caused by the meeting of winds from different sources, one warm and moist and the other dry and cold. These may meet laterally, or there may be an overturning of the atmosphere when they suddenly meet above. The latter idea is theoretically the nearest approach to what is sought by advocates of explosions as a means of causing rain to fall. The sudden conversion of a solid explosive substance into gases, perhaps 1,500 times greater in volume, is accompanied by tremendous expansion, force, and heat. This would drive the air about in every direction, and until diffusion of the gases took place would create a state of atmospheric instability, condensation first taking place aloft, then possibly drops falling and introducing a cooler current around, which might cause local showers, such as fall during thunderstorms from the cumulus or anvil shaped clouds caused by "unstable equilibrium." For such effect, I watched most carefully, but in this direction the explosions had apparently no more effect on the vast expanse of the air than would the striking of a match in a room.

The forces arrayed against artificial changes in the atmosphere are tremendous—almost beyond conception. A unit of heat is the amount needed to raise the temperature of a pound of water 1° Fahr., but about a thousand units are needed to transform a pound of water into a pound of vapour. When vapour turns to water, latent heat is liberated in a corresponding amount. Now, an inch of rain corresponds to 22,635 gallons, or 101 tons 3 qr. 26 lb., of water to the acre, or over 64,640 tons to the square mile. The heat developed or released under such conditions of condensation from vapour to water for an inch of rain to the square mile is estimated as equivalent to the work done by 100,000,000-horse power for half an hour. Consider again the sweep of a wind, five hundred miles across horizontally, and three miles high, blowing for an hour at the rate of twenty miles. The force of the mightiest explosion with all its gas put forth into the air is in comparison less than a drop in a bucket.

Firstly and lastly, rainfall is concerned with temperature in its relation to the aqueous vapour. Air at different temperatures will hold different quantities of water-vapour, which is an invisible gas, and lighter than the air itself. For example, at 8° Fahr. 2 cubic feet of air will sustain 22 grains weight of vapour, at 60° the same measure would hold 11½ gr., but at 32° only 4½ gr. Any additional moisture would be condensed at those temperatures, or a lowering of the temperature would have the same effect—namely, condensation. At ordinary temperatures the capacity of the air for vapour is doubled for every 18° Fahr. Cooling the air by mixture of a cold upper current with a lower warm and vapour-laden one, the meeting of tropical and polar winds in circulating storms, a warm and moist air impinging on a cold surface, would condense the vapour into dew, fog, rain, or snow; and, on the contrary, a warm surface would evaporate water by the conduction of the heat from the ground. Until it can be shown that the temperature of the air can be controlled by gigantic cooling operations, we may look in vain for any alteration in the natural and well-established order of events by way of the production of artificial rain.

In ancient times, and long before European settlement, trees seem to have flourished in the Oamaru district, for I am told that big roots are still found in the soil; but, except around the homestead, the country is now very bare of trees. Around their homes the settlers have mostly planted pines, which have flourished wonderfully; but if larger and more varied plantations were made, particularly in belts intercepting the north-west and south-west winds, though they might not increase the rainfall, yet the trees would not only act as shelters and windbreaks, but also conserve the rainfall which now occasionally runs off in floods. Where possible, the planting of deep-rooting rather than surface-rooting trees of a deciduous kind would bring up water from the lower water-tables, and not only prevent surface evaporation by the winds, but also, as the trees transpire freely in the summer, would create a beneficial humidity in their neighbourhood. The

excessive heat of a bare sunbaked soil drives away the rain from a drought-stricken district, and thus diminishes that "probability of rain" which could from time to time otherwise be reasonably forecast. So far as one can see, the only objections which can be urged against the planting of trees are the occupation of fertile lands by comparatively unproductive trees, and the possible harbouring of the small-bird pest. The losses, however, would undoubtedly be more than compensated for by wider general benefits, and the whole question is one which assuredly concerns the community at large, and could with advantage be dealt with by local or General Government regulations.

Action with regard to both the planting the destruction of trees is a matter of vital importance to the country. Whether forest-trees increase the rainfall, or are themselves the result of an abundant precipitation, is not the question one would raise at the present time, but, rather considerations of evaporation, shelter, run-off, &c., as affected by tree-planting, and which are of more than passing interest to the people of Oamaru.

In conclusion one would like to remark that, though our seasons are usually so temperate, regular, and fruitful, yet the climatic conditions are of the greatest concern to the country.

Approximate Cost of Paper.—Preparation, not given; printing (1,300 copies), £8 16s.

By Authority: JOHN MACKAY, Government Printer, Wellington.—1908.

Price 6d.]