Weather Recurrences and Weather Cycles.¹

By Sir RICHARD GREGORY.

EVERY year the weather is in some sense abnormal, but the past twelve months have given us rather more than our fair share of extremes, beginning with the most severe winter since the famous frost of 1895, continuing through several long periods of drought to the rainiest November on record. Unusual weather always leads to much discussion in the Press of the time-honoured subject of weather cycles, and 1929 was no exception. The point that the interval of thirty-four years since 1895 was within a year of the famous Brückner cycle was not missed, and the spells of cool rainy weather which tempered the dryness of spring and summer have been widely hailed as manifestations of the 'Buchan cold spells'.

Buchan, it may be recalled, was much interested in tracing annually recurrent spells of unexpected weather. Thus a cold spell has been stated to occur regularly early in May, and has been associated with the so-called 'ice-saints'. Various explanations have been offered to account for this cold spell, the most popular being that in the course of the regular annual series of pressure changes which result from the increasing power of the sun in spring, an anticyclone develops over northern Europe at the time and causes a period of north-easterly winds. Another cold spell is supposed to occur in June, caused by the development of monsoon winds blowing into the interior of Europe. Buchan in 1869 enumerated as many as nine such periods, to which he assigned the following dates:

Cold Periods.

1. Feb. 7-14.
2. April 11-14.
3. May 9-14.
4. June 29-July 4.
5. Aug. 6-11.
6. Nov. 6-13.

Warm Periods.

1. July 12-15.
2. August 12-15.
3. Dec. 3-14.

These nine periods were deduced from observations in Scotland during a period of ten years in the middle of the nineteenth century. In spite of this limitation, however, they have been assumed by many newspaper correspondents to be equally valid for the temperature of London in the twentieth century. Such an assumption is quite unwarranted, and Buchan, if he were alive to-day, would be the first to reject it. No scientific evidence has ever been adduced that cold or warm periods have any tendency to occur in London on Buchan's dates.

Alone among modern weather cycles, that of thirty-five years has a background of tradition, for it was described by Sir Francis Bacon before 1625. Many people are familiar with the passage from his essay "Of Vicissitudes of Things":

There is a toy, which I have heard, and I would not have it given over, but waited upon a little. They say it is observed in the Low Countries (I know not in what part) that every five and thirty years the same

kind and suit of years and weathers comes about again, as great frosts, great wet, great droughts, warm winters, summers with little heat, and the like, and they call it the prime; it is a thing I do the rather mention, because, computing backwards, I have found some concurrence.

This weather cycle was rediscovered and carefully investigated by the late Dr. Eduard Brückner, then professor of geography at the University of Bern, and it is now known generally as the Brückner cycle. His great work, "Klimaschwankungen seit 1700, nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit", published in 1890, has become a classic for the patient collection and analysis of material from a great variety of sources. He studied all the long records of rainfall, pressure, and temperature available at the time, and carried the record back into earlier centuries by utilising the variations of level in the Caspian Sea and other lakes in enclosed basins and in the great river systems of the world, the historic variations of ice conditions on the rivers of Europe, the dates of the wine harvest, and the frequency of severe winters.

From all this material Brückner deduced the existence of a long succession of cycles—series of generally warm and dry years alternating with series of generally cool and rainy years. From A.D. 1020 to 1890 he found twenty-five cycles, giving an average length of 34.8 years, but the individual cycles varied between twenty and fifty years. With this in mind, we must not expect too much from the Brückner cycle, for so great is this variation that only one cycle out of five comes within $2\frac{1}{2}$ years of the expected length. When in addition one remembers that the amplitude of the variations is so small that in meteorological statistics the existence of the cycle can only be seen at all as the result of extensive smoothing, it becomes obvious that the Brückner cycle is useless for the purpose of making long-range forecasts of weather, and the interval of thirty-four years between the cold winters of 1895 and 1929 takes its proper place as a mere coincidence.

The true value of Brückner's work lies in a different direction. Although the amount of rainfall may vary widely from one year to the next, the quantity of water which is stored up on the land areas, in the soil, in lakes, and in glaciers, varies far more slowly. This stored water is not so closely related to the rainfall of the one preceding year as to the average rainfall of the ten preceding years, and if these ten years fall in the wet half of a Brückner cycle, the quantity of stored water will be great. Again, in the dull rainy countries of north-west Europe, warm dry years are favourable for crops and vegetation, and on the whole the dry warm half of a Brückner cycle will yield better crops than the cool wet half, although there may be wide variations from one year to the next. An agricultural community must take the bad years with the good, and trust to the surplus from a rich

¹ From the presidential address to the Royal Meteorological Society delivered on Jan. 15.

harvest to tide over a year of dearth; but at the end of the warm half of the cycle the community will be prosperous, while at the end of the cold half it will be poor. Hence waves of emigration and the movements of peoples are closely related to climatic cycles such as Brückner's, which in this way may leave their mark on history. That, and not long-range forecasting, is the rôle of the weather cycle.

In the rainfall of Great Britain the Brückner cycle is far less important than one of fifty years. The authoritative pronouncement made by the Council of the Royal Meteorological Society in the matter of the supposed influence of broadcasting on weather contained a passage pointing out that groups of wet years in England have occurred about 1770, 1821 to 1830, 1871 to 1880 and 1922 to 1928, four recurrences at intervals of about fifty years, separated by groups of dry years in 1741-50, 1801-10, 1851-70 and 1891-1910, the inference being that the wet years since 1922 were due to some natural period of oscillation of the rainfall, and not at all to the relatively small electrical disturbance of the ether by human agencies.

Much attention has been given to the sunspot cycle in relation to weather, and the literature of this subject is enormous. Sunspots are a useful index of the activity of the sun, and they go through a not very regular cycle with an average length of 11.25 years. Taking account of the change of polarity discovered by Dr. G. E. Hale, it is more accurate to say that sunspots go through a double cycle of 22.5 years. In terrestrial phenomena, these changes of solar activity are accompanied or closely followed by fluctuations in the elements of terrestrial magnetism and by variations in the frequency of auroræ. In matters of weather, a connexion with temperature was first suspected by Ricioli so early as 1651, and was clearly demonstrated, for tropical regions, by W. Köppen in 1873. A fairly close relationship has been traced by Dr. C. E. P. Brooks between the sunspot number and the rainfall in certain parts of equatorial Africa, especially the plateau of Lake Victoria, and the eleven-year cycle in the level of this lake, which rises and falls with the rise and fall of solar activity. This is one of the most striking illustrations of the connexion between solar and terrestrial phenomena, as may be seen from the accompanying diagram (Fig. 1), reproduced from Dr. Brooks's memoir.² A similar relationship is found in Lake Albert and farther south in Lake Nyasa, though in the latter it is somewhat obscured by the large annual variation in the level of the lake and by other factors.

In Great Britain the eleven-year sunspot cycle, like the Brückner cycle, is of little importance.

Although we are undoubtedly governed in the long run by solar influences, these find their way from equatorial to temperate latitudes by many and sometimes devious routes, winds, ocean currents, and so forth, so that their unity becomes lost and they appear as an irregular series of changes following no apparent law. For example, it was found by Dr. G. Hellmann that the rainfall of Europe has two maxima and two minima in each sunspot period, and he explained this as due to the combination of two causes, the direct effect of the solar variations on the weather of Europe and the indirect effect due to changes at the equator extending their effect northwards. In 1928, Dr. Brooks, after an examination of the relation between sunspots and pressure, both at individual stations and the distribution of pressure as a whole, concluded "that at present the variations of sunspots in the eleven-year cycle cannot be taken into account in predicting quarterly mean deviations of pressure in the eastern North Atlantic or western Europe.

FIG. 1.

The suggestion has been made, notably by Defant, that there is a natural period of about $3\frac{1}{2}$ years in the oscillation of the earth's atmosphere, which requires to be set going by some vigorous impulse; Defant found such an impulse in a violently explosive volcanic eruption. Others, notably Sir Norman and W. J. S. Lockyer, have found in them yet another manifestation of solar influence, such for example as is shown in the distribution of solar prominences. In some parts of the world, notably the East Indies, these periodicities of a few years are of undoubted value in forecasting the general rainfall some months ahead; in Great Britain they have at times reached a spectacular development, but always, just when they seemed to have established themselves thoroughly, they changed the length of their phase, or otherwise proved themselves unstable as water.

As the result of a great amount of research into a single definite problem, Mr. J. Baxendell was able to show in 1925 that we possess more exact information about a 5.1-year periodicity in British weather than about any similar phenomenon. The story of this period, as unfolded by the late Carle Salter and J. Glasspoole, begins in 1868. For fifteen years, up to 1882, each fifth year (1872, 1877, 1882) was very much wetter than any

² Air Ministry, Meteorological Office. *Geophysical Memoirs*, No. 20. (London: H.M. Stationery Office, 1923.)

of the remaining twelve. Then this series broke down, but from 1889 until 1909 there was a most remarkable sequence in which every third year was abnormally wet. The years 1891, 1894, 1897, 1900, 1903, 1906, and 1909 were all wetter than the average; of the remaining eighteen, one was exactly normal and the others were all dry. After 1909, however, the sequence changed to an

almost equally remarkable two-year oscillation. From 1910 until 1922 the even years were all much wetter than the average, while the odd years were all dry, with the sole exception of 1915, and even that year was drier than either 1914 or 1916. After 1922 this two-year sequence broke down, and now we seem to have returned temporarily to the three-year type.

Progress in Naval Engineering.

By Eng. Capt. EDGAR C. SMITH, O.B.E., R.N.

THOUGH surpassed in length by the presidential address of Sir William White to the Institution of Civil Engineers in 1903, the Thomas Lowe Gray lecture delivered to the Institution of Mechanical Engineers on Jan. 3 by Engr. Vice-Admiral R. W. Skelton, Engineer-in-Chief of the Fleet, on progress in marine engineering, bears comparison with it as an authoritative official review of an important subject. While Sir William White traced the evolution of mercantile and naval vessels, Admiral Skelton confined himself to the progress in marine machinery, and his lecture is probably the most extensive survey so far written. His predecessors, Admirals Durston, Oram, Goodwin, and Dixon, in their addresses and papers to the technical institutions, have all dealt with various aspects of naval and marine engineering, and were the series of contributions collected in a single volume it would go far towards filling one of the many gaps in the literature of engineering history. Such a volume should at least be available in every man-of-war and every school where marine engineering is studied.

Though not mentioned by Admiral Skelton, the first suggestion for a steam-driven war vessel was made to the Admiralty by Earl Stanhope. For him the authorities built the 'ambinavigator-ship', called the *Kent*, and so sure did Stanhope feel that he was on the high road to success that in June 1794 he signed a bond with a penalty of £9000 "to indemnify the public in case the said ship should not answer the purpose of Government". The inventor did not merely intend to produce a result, but he hoped "to establish every part of the subject on clear and irrefragable proofs, and to ascertain demonstratively what is the best possible plan". The experiments failed and the matter was dropped, without Stanhope, however, being kept to his bond. Twenty years elapsed before the Navy had anything more to do with steam, and then the suggestion came from Sir Joseph Banks. Capt. Tuckey was preparing for surveying the river Congo in the *Congo*. Why not fit her with a steam engine? Constructed by the greatest engineering firm in the world, Boulton and Watt, the engine was delivered, put into the ship, taken out again and set up in Chatham dockyard. So heavy was the machinery that the *Congo* would have foundered in any sort of sea, and Capt. Tuckey therefore wisely decided to stick to sails. Five or six years passed and with the building of the *Comet*, *Lightning*, and other small

steam craft began a series of revolutionary changes in everything pertaining to warships.

It cannot be said that early naval requirements made any severe call on the engine constructors of the day. Fulton had launched the *Clermont* in 1807, Bell the *Comet* in 1812, and steam vessels were proving their worth on every ocean. But few realised the value of steam in war vessels, and there was no more stubborn opponent of steam than Capt. Sir William Symonds, the Surveyor of the Navy. The Russian War of the 'fifties, however, showed the futility of any longer trusting exclusively to the wind, and on April 22, 1854, the officers and men of the Black Sea fleet saw for the last time a British frigate in action under sail. By that time, slow as progress had been, the paddle had given place to the screw, the flue boiler to the tubular boiler, engines were becoming more powerful, and many of the younger generation of naval officers, who knew more about railways and electric telegraphs than of the fighting of the Napoleonic wars, had eagerly taken up the study of engineering.

Admiral Skelton gave much interesting information regarding those early days, and then proceeded to review matters which are more familiar to our ears. He was unable to read the whole of the lecture, which, however, will be published in full by the Institution of Mechanical Engineers. When available it will be seen to contain as an appendix a tabulated statement of some forty ships, from the fine paddle frigate *Terrible* of 1842 to the cruiser *Berwick* of 1925. It is a happily chosen list, and the progress of naval engineering could well be traced by a study of a ship from each decade. The fourth ship in the list is the *Agamemnon* of 1851. Other wooden two-deckers had been altered to receive the screw, but the *Agamemnon* was the first of her class to be designed as a screw ship. Her engine by Penn would reflect credit on any shop to-day. It was a simple expansion horizontal engine with two cylinders fitted with trunk pistons something like the pistons found in a motor-car. The square tubular boilers generated steam at 20 lb. pressure, and the engine developed 2268 h.p. The machinery weighed 320 lb. per h.p., cost £15 9s. per h.p., and consumed 5 lb. of coal per h.p. per hour. Compare this with the *Berwick*, the machinery of which, developing 80,000 h.p., weighs only 45.5 lb. per h.p., cost but £5.6 per h.p., and consumes only 0.89 lb. of oil per h.p. per hour.

Under the command of Capt. W. R. Mends the