Radio Communication and Imperial Development.[1]

By Dr. W. H. ECCLES, F.R.S.

THE British Empire is a medley of fragments spread as if by blind chance over the habitable portions of the globe. Looked at in Mercator's projection, it is like a broken potsherd on the floor—a collection of large pieces and small pieces, at all distances apart. Yet, scattered as they are, these pieces of earth bear populations which instinctively turn to the mother country as the centre of that world which lies beyond their immediate interests. This is as true of the large pieces as of the small.

For so dispersed a family, the problem of telegraphic communication is important and difficult. Until the year 1902, long-distance telegrams were all carried by cables, under the sea or under the ground, and by wires on poles; and the task of serving sparsely populated and distant regions required capital outlay beyond reason. But between 1902 and 1904, in a series of bold experiments, Marconi proved that messages could be conveyed thousands of miles by telegraphy without wires. Then he and many others showed that electric waves can pass over mountain chains, and even far round the bend of the globe, at any rate at night, and that they could be picked up simultaneously in all directions round their source. Here obviously was a heaven-sent gift to the British Empire, for by wireless telegraphy we might now hope to communicate, simultaneously if desired, with a thousand places to which cables and wires could never be run.

Quite early in the development of wireless telegraphy, the principal nations began to apply it and to regulate its employment. Indeed, control was compelled, in the armed camp that Europe then was, by the consideration that, when war came, wireless would be useful to fleets and armies and dangerous in the hands of spies. In peace time, even, some degree of control was called for to reduce interference, especially between powerful long-range stations. Each such station ought, in fact, to transmit on a different wave-length from other stations; and once a wave-length is assigned to a particular long-range station, it should not be given to any other. In other words, the grant of a wave-length to a powerful station is equivalent to giving a right-of-way to that station. For all these reasons the Imperial Conference of 1911 declared that wireless communication within the British Empire should always be regulated with especial care, and that, in the main, the necessary stations should be State-owned and State-operated.

This decision being given, it only remained to erect the stations. In 1912 Parliament approved a contract which the Post Office had made with the Marconi Company for the erection of a British Imperial chain of six stations. This contract was, however, modified after a technical inquiry, and a new contract was ratified by the House of Commons in 1913. But the engineers had barely time to erect a few masts at Leafield in Oxfordshire and at Abu-Zabal near Cairo, when the contract was dissolved, principally on account of the advent of war. In contrast with our inaction, the United States had meanwhile pressed on with the construction of several large government stations, and France and Germany made great progress with their respective colonial plans. Perhaps we could afford to delay. Compared with Germany, for example, we possessed elaborate cable communications, and were more confident about defending them in every sea than Germany could be. But the result was that when war broke out in August 1914, no unit of the much-discussed British wireless chain had been erected.

Germany, on the contrary, had made great strides with her colonial communications between the years 1912 and 1914. She had established thoroughly modern stations in Togoland, in German East Africa, in German South-West Africa, and in the Pacific. The three African stations could inter-communicate with one another, and, to a limited extent, with the great station at Nauen, near Berlin. The Pacific station was at Yap in the Caroline Islands. It was a noteworthy coincidence that all these stations were completed just before the War began. I remember hearing the early trial signals from Yap while I was sailing across the Pacific in July 1914. No doubt this station was intended to receive instructions from Berlin, and retransmit them to island possessions, such as Apia in Samoa, and to naval and mercantile vessels in the Pacific and the China Seas. It may be of interest to recall the fate of Yap; it is wrapped up with the story of the German Pacific fleet commanded by Von Spee, which, months later, met Cradock at Coronel and Sturdee at the Falkland Islands. I remember some of the story because I was called from Sydney to Melbourne by the Australian Government to help in an advisory way with an interesting application of wireless. At this moment the German fleet was cruising to the north of Australia and was in nightly touch with Yap. As soon as this was observed, each of the small shore stations along the Australian coast was instructed to listen for the signals of the German fleet, to record the strength with which the signals were received, and to report daily to Melbourne. From these reports, by a process resembling triangulation, an estimate was made in Melbourne of the changes of position of the fleet. Meanwhile a British naval force had set forth with the object of destroying the wireless station at Yap. This was duly accomplished, and for days afterwards the Germans, unaware of the disaster, continued to call the dead station, in vain. These continued calls, by helping us to keep track of the fleet, eased the anxiety of those who knew that the New Zealand expedition was then well on its way to capture Samoa. Thus ends the story of Yap; that of the other German colonial stations was similar.

During the War our wireless energies were deflected from the building of great stations to producing relatively small outfits for fighting purposes. War telegrams were handled sufficiently well by the cables and the wireless stations of the Admiralty, and the War closed without any progress in imperial wireless. Meanwhile the French government had erected powerful stations at Nantes, Lyons and Paris, and smaller stations in their African territories; the Italian government had erected a large modern station at Rome;

[1] From a Friday evening discourse, entitled "Wireless in the Empire," delivered at the Royal Institution on April 30.

and the United States government had completed half-a-dozen big stations, together with a magnificent one near Bordeaux which was afterwards purchased by the French government. But the governments of the British Empire, at the close of the War, stood possessed of only one fairly large wireless station among them—that at Windhuk in German South-West Africa—captured by the forces of the Union of South Africa under General Smuts. Thus at the end of 1918 the British Empire was far behind most other great Powers as regards government-owned stations, and, by the way, equally far behind as regards powerful commercial stations.

At this time Lord Milner took up the cause of Imperial communications. Lord Milner appears to have been the only elder statesman of that day convinced of the imperial value of widespread communications, and aware of our national backwardness. But he looked for much more than mere duplication of cable- and land-line services. He envisaged the possibility of radiating daily from England and other great centres news and opinions of imperial interest in such a form that they could be picked up, perhaps after re-transmission by outpost stations, anywhere. He thought it wrong to continue to leave a large proportion of the population of the British Empire as isolated as if cast away on a raft in the ocean. I believe he thought that wireless would be as useful for the cultivation of mutual understanding as for strategy and commerce. In other words, he realised fully the importance of propaganda, and holding these views, advocated government expenditure on improving radio communications.

Within a year of the conclusion of the War, Lord Milner appointed a committee, under the chairmanship of Sir Henry Norman, to investigate afresh the problem of establishing a comprehensive wireless network. The committee found that the progress made in wireless during the War had completely changed the outlook. Plant was now available of at least double the effectiveness of the pre-War wireless chain proposals. Accordingly the Norman committee recommended that wireless stations of about 250 kilowatts power, giving 120 kilowatts of continuous wave power to the antenna, should be erected in Egypt, East Africa, South Africa, India, Singapore, Hong Kong and Australia, with, possibly, similar stations in Canada for trans-Atlantic and trans-Pacific communication; and that a station of double the power of the others should be erected in England. Stations such as these, it was thought, would each be able to communicate at all hours with its nearest colleague even under the very bad conditions that afflict wireless reception in the tropics; and each would communicate with its most distant colleague during at least a few hours daily. The scheme ensured that each point would communicate with every other at all times; directly when conditions were good, indirectly—that is, by the relay or passing-on principle as used in cable telegraphy—when conditions were bad. The English station being the most powerful of the network would have the maximum amount of direct communication with all. Besides this, the scheme would enable the Admiralty to transmit instructions from Whitehall to ships afloat anywhere, a requirement included in the terms of reference of the committee.

At this date there were no wireless stations in existence as powerful as those recommended, and, therefore, it was difficult to forecast what their performance would be. Moreover, the committee recommended that the stations should be equipped with thermionic valves. Now the largest valve station then known was of less than 20 kilowatts output, so the recommended English station was to be more than twelve times as powerful as its largest predecessor. The report was, clearly, somewhat ahead of its time, but not, I think, too far ahead. For by the year 1925, only five years later, the Post Office station at Rugby has been built with thermionic valves yielding double the output recommended by the committee. The Rugby station has shown besides, during the tests of the past few months, what the Norman committee's stations could have done. For example, the station recommended for South Africa would have communicated direct with England, Australia and India many hours each day, and the English station would have worked direct to the antipodes more than twelve hours daily.

Lord Milner on receiving the report was, I believe, especially pleased that stations were proposed for some of the dependent Colonies, such as East Africa, Singapore and Hong Kong; not merely because they would serve at times as telegraphic links between England and some of the great Dominions, but as ends in themselves. These intermediate stations would bring great areas of new country into closer touch with all other parts of the Empire. Lord Milner was convinced that the dependent Colonies had for many years past been neglected, and that wireless telegraphy would help to alter this state of things. So at the end of 1920 the Cabinet appointed the Wireless Telegraphy Commission, of which Lord Milner became chairman, and officially assigned to it the task of getting as much done as it possibly could.

As no station could be erected until the requirements of all parties could be co-ordinated, the first task was to obtain unanimous consent to the scheme or a modification of it. It was unfortunate that Lord Milner retired from political life before any decisions were reached by the Dominion Governments. As it turned out, each Dominion Government held a different view about Imperial wireless, partly as to the financing and management of it, partly about the technical requirements and possibilities. The only common element was that they each desired to communicate with England without intermediate steps. Thus as fast as each Dominion settled its policy, a new compromise had to be framed for the Cabinet's approval. Finally, when Mr. Amery was chairman of the Imperial Communications Committee in 1923, Empire wireless took a new spring. The Government decided to erect in England without further delay a wireless station powerful enough to transmit almost continuously to all the Dominions and dependent Colonies, and to all ships of the navy and the mercantile marine wherever they might be.

The time of waiting had not been lost. The Commission had proceeded a long way with the plans of a large station, and the Post Office engineers had gained much experience by equipping with up-to-date plant the medium power stations at Leafield and Abu Zabal, remnants of the old Imperial scheme of 1913. As a consequence the erection of the Rugby station,

the most powerful in the world, has gone forward with exemplary smoothness and without accident or failure of any kind. The Rugby station when in full swing will probably be able to transmit simultaneously three long-distance telegrams and a telephone message. The ultimate aim of the telephone section is to connect any telephone subscriber in Great Britain to any subscriber in the United States and Canada. By aid of the telephone circuits already constructed between England and the Continent, it may be found possible later to connect any one in western Europe to any one in North America through Rugby.

When it is realised that this multiple service station has cost only about half what the single service station near Bordeaux cost in 1919, one appreciates the great strides that wireless design has made during the past few years. Rugby, in fact, has cost about 400,000*l.*, much less than even the new stations at St. Assise near Paris and on Long Island near New York. Further, as the Leafield station began to earn, within a year of its opening, more than covered its working expenses, so we may reasonably look forward to the Rugby station soon becoming a profit-earning concern.

It has always been obvious that the telegraphic traffic to and from the centre of the British Empire will be greater than that to and from any of the Dominions; for the centre has to deal with all the Dominions, all the dependencies and with distant shipping. The spokes all meet at the hub of the wheel. Therefore Britain must make much greater provision than even the largest Dominion, perhaps tenfold. Definite recommendations for the erection in England of stations additional to Rugby were made in the report of the Imperial Wireless Telegraphy Committee, February 1924, presided over by Sir Robert Donald. An opportunity of meeting the recommendations came in the summer of 1924, when the British Government, finding the majority of the Dominions would probably agree to use the Marconi beam system, made a contract with the Marconi Company which will result in the establishment of duplex beam circuits between Canada and England, Australia and England, South Africa and England, and India and England. The arrangement promises a happy solution of many long-standing difficulties. These beam stations are now nearly completed. A transmitting station at Bodmin serves Canada and South Africa, and a station at Grimbsy serves both Australia and India. Corresponding stations are being erected in the four Dominions.

The beam stations may claim to send their messages straight to the desired objective since the guaranteed angle of concentration of the waves is 30°. There is the additional advantage that little power is consumed, partly because of the concentration and partly because short waves are used. This again implies small capital outlay, so at first it was thought that suitable beam stations would be very inexpensive. In practice the engineers met many snags, and it is probable that the English beam stations for communicating with four Dominions will cost altogether about half as much as Rugby. For this expenditure good communication is guaranteed for a daily average of 18 hours with Canada, 7 hours with Australia, 11 hours with South Africa, and 12 hours with India.

It has been suggested that beam stations may some day supersede the wireless stations which send their waves all round. This kind of controversy is always going on in wireless and other progressive sciences, and sometimes tends to cripple action to-day by promising cheaper alternatives to-morrow. As an example, when the motor-car gained its first successes we were told that railways were obsolete; but one can still travel by train from London to Edinburgh more comfortably, more cheaply, and more quickly than by car. As regards the wireless problem, the present beam stations are the first of their kind and have not yet been operated. We only know enough to say that both systems will be useful, and that each can do something the other cannot.

Before the end of this year the long-range wireless transmitting equipment of the British Empire will include—

(1) The multiple station at Rugby, comprising:
  (*a*) Long wave plant of world-wide range.
  (*b*) Long wave plant of medium range.
  (*c*) Short wave plant of world-wide range.
  (*d*) An experimental telephony plant of range 4000 miles.
(2) Medium power stations using long and short waves at Leafield, Oxfordshire, and at Abu Zabal, Egypt.
(3) Four duplex beam circuits for communication between England and the four largest Dominions.

Thus by the efforts of the engineers of the Post Office and the engineers of the Marconi Company, the British Empire will shortly possess the most up-to-date wireless equipment in the world.

So far I have dealt with things nearly completed, but now I must indicate briefly what has yet to be attempted and is within reach. In the first place, there are important communities still unprovided with long-distance wireless; for example, New Zealand. This urgent necessity was emphasised in the report of the Donald committee. In the second place, preparations ought to be made to utilise fully the new facilities. For example, twice a day Rugby transmits a summary of news prepared by the Foreign Office, and conceivably other news services may be arranged. If I were a settler in Uganda or the owner of a remote sheep station in Australia, I should install a simple receiving set and so keep in touch with the world. But this implies learning the morse code, not so hard as learning to use a typewriter, but still a difficulty; and therefore in small communities where there is a local news sheet, it would be more practical to organise a receiving service by paying an operator to listen regularly and decode the messages for the printer. In the British Empire there are innumerable remote settlements to which the cabled news messages leak very slowly, and there are many which depend entirely for their news on the occasional visit of a ship. All such outposts can now, by the aid of a simple receiving set, be made to feel that they are within five minutes of Fleet Street. Moreover, if these stations were registered, messages could be specially addressed to them from England just as telegrams are addressed from Rugby to-day to ships on distant oceans.

Another method of distributing the morse messages from home when received, say in New Zealand, is to

announce them, after decoding, through the local broadcasting stations. In each of the Dominions such stations are growing in numbers, and by their aid messages could be distributed promptly to millions of listeners-in. Of course it may some day be possible, after further invention and development, for speech and music from England or other centres to be put on to every local broadcasting station in the British Empire.

This does not exhaust the possibilities now arising. During the past two or three years wireless amateurs have succeeded in transmitting signals and even speech across vast distances with tiny apparatus. The plant used is so small that it could be installed in a drawing-room. If only we could rely upon plant of this size getting through for days instead of hours, then there would be no need for high-power stations. Even so it is easy to imagine how such glimpses of intercommunication might be made use of in the elaboration of Empire wireless.

The chief results expected from all these efforts to establish an Imperial wireless network can be put in two sentences. Firstly, mutual trade will be facilitated by rapid and cheapened communications, and finance will benefit by a shortening of credit such as followed the introduction of the cables. Secondly, the interchange of opinion between all sections of the British Empire will become fuller; and just as wireless on the small scale has become, in the shape of broadcasting, an important social influence in Great Britain, so wireless on the large scale will have a similar influence in, and strengthen the unity of, the British Empire.

Segregation and Related Problems.

THE laws of evolution and heredity have generally been regarded as universal in their application both to plants and animals. The various theories of evolution have been held by their authors to apply indiscriminately to both kingdoms, and the same has been true of theories of heredity and, with certain limitations, of cellular structure and mitotic division. But there are signs in the more recent developments of genetics that these general resemblances, fundamental as they are, have been over-estimated. In the future, we may expect to see greater emphasis laid on the distinctions, many of which are also fundamental, between animal and plant structure, especially as they affect variations and hereditary behaviour.

The tendency to recognise a divergence between plants and animals in certain aspects of their genetical and evolutionary behaviour has become increasingly evident, both on the breeding and on the cytological side. This tendency is well exemplified in the recent paper on segregation, by Bateson (*Journ. Genetics*, vol. 16, No. 2), the last, unfortunately, which he published before his lamented death. It was the Leidy Memorial Lecture delivered at the University of Pennsylvania in 1922, and in it the greatest biologist, perhaps, of his generation discusses the nature of segregation and the various problems connected with it. In recent years the Merton Laboratory had made extensive studies of variegation in many plants and of various forms of somatic segregation, especially from root cuttings. These in Bateson's hands furnish the basis for a consideration of the nature and significance of the many forms of segregation observed. The fact emerges that not only are most of these forms known only in plants, but also that somatic segregation when it occurs in animals is usually quite different in genetic behaviour and significance.

The term *anisogeny* is introduced for the numerous cases now known in Matthiola, Oenothera, Linum, Campanula, Begonia, and other plants, in which the male and female gametes are carrying separate factors, and it is not clear that this is always due to the loss of one class of gametes after segregation in meiosis. Not only does the place of segregation vary in the many kinds of somatic segregation now known, but also it has been shown by Miss Andersson in the variegated hart's tongue fern that all the 64 spores of any sporangium are alike in the form of plastid they transmit, this depending only in part on the plastid characters of the vegetative tissue from which the sporangium arises. The well-known experiments with rogue peas, made by Bateson and Punnett, Miss Pellew, and others, indicates that here is an orderly type of progressive somatic segregation occurring from below upwards in the plant and accompanied by anisogeny.

Bateson returns to the presence-absence hypothesis and makes out a case for it, based particularly on the interpretation of multiple allelomorphs; for example, the yellow 'eye' series in *Primula sinensis* and the colour series in rabbits. These, as he points out, characteristically form a plus or minus quantitative series as regards one character. The quantitative interpretation of a multiple allelomorphic series is very probably correct; but even so, any advantage of the presence-absence conception appears to be merely a matter of convenience in symbolism. It is, of course, possible that all variations are in essence quantitative. We seem to be arriving at a position in which no essential difference remains between the presence-absence conception and that of each pair of allelomorphs as the result of a germinal change.

In the same number of the *Journal of Genetics*, Castle, Punnett, and Pease continue their discussion of the various types of 'Dutch' rabbits, which have taken the place of the hooded rat as material for the explanation of an apparently continuous series of variations. Castle contends that Self, Dark, and White Dutch form an allelomorphic series, together with modifying factors, while Punnett argues that Dark Dutch is the basic condition, which becomes self-colour through the addition of modifiers. It would follow that an allelomorphic series is not involved in this case; but to settle the matter finally a further study of the linkage relations may be required.

It is clear that segregation remains the central conception in modern genetics, the science which Bateson founded. But it takes a great variety of forms, particularly among plants. Their further elucidation will lead us into new fields.

R. RUGGLES GATES.