

DEMONSTRATION OF AN ELECTRICAL METHOD OF PRODUCING VOWEL SOUNDS AND ITS APPLICATION TO WIRELESS TELEGRAPHY.

By Dr. W. H. ECCLES, *F.R.S.*, and C. F. A. WAGSTAFFE.

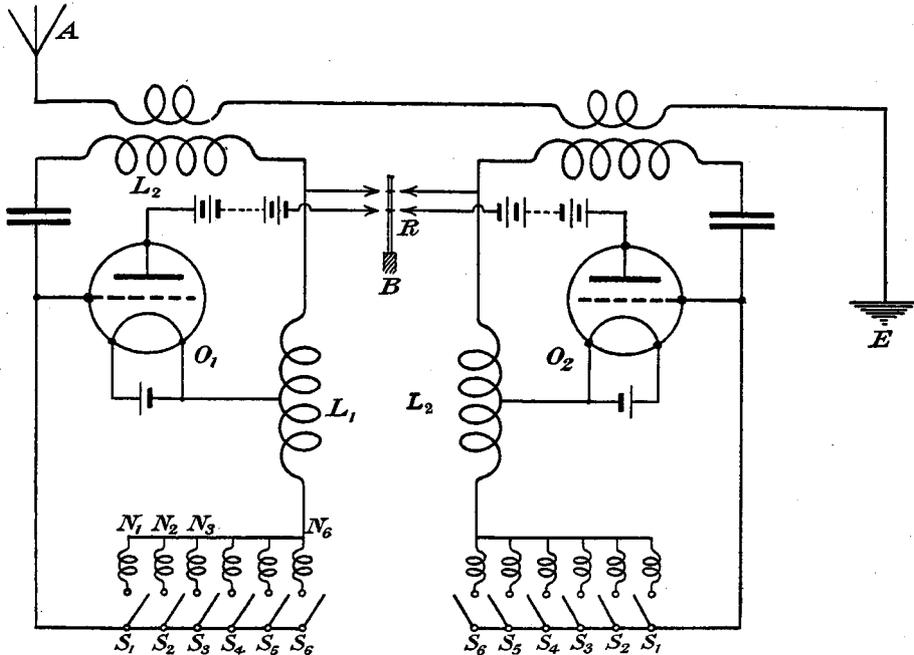
THE apparatus to be shown represents wireless sending and receiving stations. It was devised to test a proposed method of communication in which the electric waves transmitted could produce easily recognizable chords at a suitably equipped receiving station. It was thought that chords would be more easily recognised than simple tones, and that vowel sounds would be the most easily recognised of chords.

The ideal aimed at in this method of communication is that an operator at one side of the ocean should converse with an operator at the other side by means of a language made up of vowel sounds (somewhat like the Hawaiian language), the sounds being produced by pressing keys. Any ordinary language could be converted immediately into this telegraphic form by a code wherein each consonant was represented by a definite pair of vowel sounds.

Consider the problem of transmitting the vowel *ah* from a wireless station utilising a frequency of, say, 100,000 cycles per second. One way is to pronounce the vowel in front of a microphone arranged for wireless telephony. But if the human voice is not to be employed, if, in fact, an artificial vowel sound is to be produced by pressing a key, vibrations of a voice frequency such as 250 cycles per second must be combined, according to the analysis of Sir Richard Paget, with the characteristic frequencies 800 and 1,300. Then these must be impressed upon the oscillations of 100,000 frequency by a microphone or otherwise. The simplest electrical solution is to employ a buzzer of frequency 250 cycles per second to excite at each stroke two circuits tuned respectively to 800 and 1,300 cycles per second, and to pass the complex currents through a telephone to convert them to sound waves. Such an apparatus has been used for testing telephones by the Western Electric Co. without any thought of applying it to wireless signalling. For this latter purpose the sound from the telephone could be applied to a microphone, or, alternatively, the complex currents could be used directly to modulate the high-frequency oscillations.

The method to be described is, however, more direct than that just suggested, and currents of acoustic frequency need not appear at any stage earlier than in the telephones of the receiving operator. Broadly, the method is as follows: At the transmitting station the pressing of a key produces immediately electrical oscillations of frequencies 100,800 and 101,300, and waves of these two frequencies are radiated. At the receiving station the waves produce corresponding oscillations, and these are combined with a locally generated frequency of 100,000 cycles per second in the well-known "heterodyne" manner so as to produce currents of frequencies 800 and 1,300. In order that these should together simulate the vowel sound *ah*, a current of voice frequency, say, 250 cycles per second, should be superimposed in a suitable way; this may be done either before the oscillations leave the sending station or after they reach the receiving station. Each method has given good results with a variety of vowels, made up by taking Paget's table of vowel constituents.

Three distinct ways of carrying out the above conception have been tried successfully. In the first of these ways a pair of oscillating circuits, which may be coupled together in any manner, or which may be completely separated, are adjusted to have the two natural frequencies of, say, 100,800 and 101,300, and are excited by "musical spark plant of, say, 250 cycles per second. The consequent oscillations are passed to the sending antenna. If the two circuits are coupled and excited by one and the same spark, the two frequencies natural to the coupled circuits are partly determined by the coupling. At the receiving stations the oscillations are amplified if necessary and heterodyned by aid of a local oscillator of



A ANTENNA. E EARTH. O₁ TRIODE OSCILLATOR FOR UPPER FREQUENCIES.
O₂ TRIODE OSCILLATOR FOR LOWER FREQUENCIES.

frequency 100,000 per second. The resulting compound current is rectified in any manner and passed to the operator's telephones. The tone heard there possesses the quality of the vowel *ah*. Other vowels can be made similarly by associating other high-frequency circuits with the same spark apparatus, and thus intelligible signals can be transmitted by aid of a code. Instead of the heterodyne the apparatus known as the tone wheel and other apparatus may possibly be employed.

The second way of working employs two sources of continuous waves, one of frequency 100,800, say, and the other of frequency 101,300 to produce waves. The sources are modulated or interrupted at equal acoustic frequencies of, say, 250 per second, either by the same or different pieces of apparatus. The waves of frequency 100,800 may be emitted at the same instant of time as those of frequency 101,300, or they may be emitted alternately, as may be advantageous in cases where one

and the same interrupting apparatus is applied to both sources of continuous waves. In this latter event a physiological phenomenon which may be called the persistence of audition has been discovered and is relied upon to blend the results at the receiving station. Reception is carried out by heterodyning at 100,000 per second or by an analogous process. The sound heard in the telephones has the quality of the vowel *ah* superposed upon a "voice" of frequency 250 per second. The figure shows diagrammatically apparatus suitable for this latter way of working when six vowel sounds are to be produced and employed. It consists of two similar triode oscillators O_1 , O_2 , each capable of oscillating at any one of six chosen frequencies. The choice of frequency is given by the switches S_1, \dots, S_6 . When S_1 is closed, the inductance in the left-hand oscillating circuit is made up of the coils L_1 and L_2 and N_1 ; when S_2 is closed, N_2 is substituted for N_1 ; and when S_3 is closed, N_3 is substituted. The respective circuits so formed are conveniently tuned to the desired frequencies by moving the N coils with respect to the L coils whereby the mutual inductance between the respective pairs is varied. Alternatively, small condensers have been used instead of the N coils. A buzzer B carrying a contact rod R is maintained in vibration at 250 per second and alternately stops and starts the oscillators by making and breaking their circuits. The two switches marked S_1 are closed simultaneously, preferably through insulating linkages, when a key (not shown in the figure) is depressed; the switches S_2 are similarly closed by another key, and switches S_3 by a third key. Thus by pressing one of the three keys the operator can transmit in one operation the two components which make up a "vowel" signal. It is found practicable to build and work apparatus of this type employing six vowel sounds familiar in the English language. By manipulation of the keys consonantal effects can be produced. It is not necessary to adhere to the vowel sounds of one language, or, indeed, to the vowel sounds of any existing language, in order to make easily recognisable complex sounds.

The third example of this class of apparatus employs two sources of continuous waves, one of frequency 100,800, say, and the other of frequency 101,300, to produce waves, and these are transmitted from the sending station without modulation. At the receiving station the received oscillations are heterodyned by a local oscillator of frequency 100,000 whose oscillations are modulated by local apparatus at a frequency of, say, 250 per second, and the result rectified and passed to the telephones. The "voice" heard in the telephones is of frequency 250 per second, and the vowel quality, being determined by the heterodyned high-frequency oscillations, is that of the vowel *ah*.

In the apparatus exhibited there is provided an oscillatory circuit of acoustic frequency which has been calibrated so that various settings of the condenser give to the circuit the twelve acoustic frequencies required for the six vowels. This circuit is employed as an electrical resonator for the adjustment of the heterodyne currents accurately to their correct frequencies.

DISCUSSION.

Sir RICHARD PAGET said that the Demonstration proved conclusively that effects of the kind described can actually be obtained. He would suggest experimenting with the simplest form of electrical sound-producers on the lines followed by Mr. J. Q. Stewart, of the Western Electric Company of America, in the testing of telephone receivers. In such apparatus low-frequency resonant circuits are employed and the necessity for heterodyning is avoided; and if, as the speaker believed, consonant sounds consist of not more than four components, it should not be difficult to synthesise ordinary speech in a telephone. Such apparatus would not, of course, be applicable directly to telegraphy, but would be of considerable theoretical interest.