Some Major Problems in Broadcasting.

By C. R. RUSSELL.

In this article Mr. Russell gives a comprehensive and balanced resume of the problems with which broadcasting is confronted. Great as have been the advances in recent years, much yet remains unsolved. The problems are not only mechanical, but human, and—in relation to programmes—psychological. A fuller grip of the intricacies of broadcasting will result from perusal of this article.

The layman who is shown over a broadcasting station for the first time often expresses surprise at the simplicity of operation. But behind that simplicity there are the brains of the world's foremost scientists, many years of work involving not only the electrical sciences, but those of physics, heat, light, and sound, geology, to even biology; while without the science of mathematics there would probably have been no radio, as this owes its whole existence to the work of that great mathematician Clerk Maxwell.

The function of a broadcasting station is to propagate a wave which when picked up by a suitable receiving devise within a certain range will give rise to a true reproduction of the original music or speech. Failure to observe this simple principle has been the cause of most of the interference which is now being experienced in the United States with the six hundred or more broadcasting stations.

What is Required.

From the technical point of view, then, the broadcasting station must fulfil two conditions: Sufficient volume must be produced with a certain standard type of receiver at the extreme boundaries of the territory which it serves, and the reproduction as heard from the speaker of the standard (supposedly distortionless) receiver must be an exact repetition of that given out from the instruments and vocalists in the studio. At once the question arises, is there a standard type of receiver? and is such a machine or its speaker distortionless? The answer to both questions must be in the negative. The best that we can do is to consider an average machine as one of good quality and medium price operating a cone loud speaker. Five-valve receivers of the neutrodyne type fulfil very closely the requirements of the mythical "average machine" for New Zealand. Assuming, then, such a machine we must examine the conditions which must exist at the transmitting end for production of good volume together with undistorted music.

The factors which enter into the average intensity of an electromagnetic wave, or, better still, the current flowing in the receiving antenna system, are expressed in the well-known Austin-Cohen formula, the generalised form being: 12—4.25 I, hlh2 Ld——e -ad//L.

where I1 is the sending antenna current.
I2 the receiving antenna current
h1 the height of transmitting antenna in kilometres.
h2 the height of receiving antenna in kilometres.
L the wavelength in kilometres.
a dissipation constant.
d distance between stations in kilometres.

From the above formula it can be seen that to obtain increased range the transmitting station antenna current (and hence its power) can be raised, the antenna can be made higher, and the wave-length adjusted for optimum conditions. It is interesting to note at this point that the wavelength L appears as a divisor in the equation, as well as in the exponential term, and this latter term has been for some considerable time strongly criticised by Watson, Fuller, and others, whose opinions have received strong support from experimental short-wave work.

While there are many other factors which must be taken into consideration in applying the Austin-Cohen formula, the chief points which we must take into consideration for our present purpose are that increasing the power of the transmitter, and raising the height of the antenna, will, the other factors remaining the same, give an increase of current in the receiving antenna. While we can control to a large extent the operation of the transmitter, we can do little once the wave has been propagated into space. Its peculiarities are being studied the world over by scientists, but up to date little but theories have been expounded to account for the vagaries of radio reception such as intensity variation, fading or fluctuation of received signal, variation of wave direction or polarisation, static, and interference of various kinds.

Are There Two Waves?

Recent experimental work in America would seem to show that at a short distance from the transmitting station the wave breaks into two, one following the earth, while the other travels perhaps a hundred miles above the earth's surface. The former soon decreases to a negligible value, due to the resistance of the earth, and at a distance of 200-300 miles from the transmitting station it is nonexistent, while the free wave travels on and is reflected downwards by the action of the ionised layer generally known as the Heaviside layer. The wave is also refracted, due to the action of the layer.

Fading.

Fading is one of the greatest troubles with which we have to contend, and it may be produced at the transmitter or beyond. If by any chance the voltage of the mains supplying the transmitter should vary, then, unless a regulator is installed, fading will probably take place. Fading, however, is too common to allow such an explanation to be satisfactory, and we must turn again to the wave behaviour for a source of the phenomena. Fading may occur with or without distortion, but in most cases it is the latter. Some months ago the writer toured parts of New Zealand with a portable 6-valve loop receiver and obtained some interesting data. At a distance of approximately 200 miles from Auckland 1YA was found to fade badly, accompanied by distortion; at a distance of 300 miles from this station fading diminished, and there was less distortion. The same thing happened when observations were taken of 3YA and 4YA; at varying distances between 200-300 miles from the stations fading was at its maximum, the one exception being 4YA, whose maximum fading effect appeared to be at about 150 miles.

What is the Explanation?

The fading and distortion can, I think, be explained by the aid of the two-wave theory recently tested in America. At a distance under 300 miles from the transmitter two waves affect the receiving antenna system, the grounded wave and free wave. As these waves are moving through media of different density, it is reasonable to suppose that they do not reach the receiving antenna at the same time; in other words, they are out of phase, a condition may then arise which will cause fading. The true or free wave may by refraction or absorption have a very low intensity at the receiving antenna, which will, of course, cause a decrease in the received signal strength, the bound wave is, however, of the same strength as before and is relatively stronger now in comparison with the free wave; remembering that the two waves are out of phase, the effect of the earth bound wave will be to produce out of phase currents, which will result in a distorted or garbled signal.

Round the Earth Both Ways.

Although not applicable in the case we have been considering, it is interesting to note another distortion effect which has lately been examined in Germany. It was found that the morse signals from distant high-power stations which were reproduced on a tape were being distorted. An examination by oscillagraph showed or seemed to show that a fraction of a second after the signal had been recorded another similar signal, but of much smaller amplitude was shown on the record. This later signal was thought to be due to the wave from the transmitting station passing round the earth by the longer way, and so arriving later than a wave which had travelled by the shorter path. In one instance calculations showed that the wave must have travelled at a height of 182 kilometres above the earth's surface.

Dead Spots.

New Zealand is fortunate in not being troubled to any extent with dead spots, locations where signal strength been explained in a number of ways. In Europe and America, however, this trouble sometimes occurs, and has been expalined in a number of ways. If the dead spot is within, say, 300 miles of the broadcasting station, one explanation is, that owing to the ground resistance, the bound wave is damped out, and, as the result of topographic or other local conditions, the free wave passes over the antenna of the receiver. A similar theory is that the ground wave dies out rapidly, and that the free wave is reflected or refracted by the ionized layer causing the wave to pass over the receiving station. The writer has seen examples of this phenomena in the United States, where a 500 watt station could not be heard 90 miles away in a certain location. When, however, the transmitting station wavelength was changed, the station came through with good strength. The explanations for dead spots are not very satisfactory, and it is much more probable that the receiving station is screened by local topographic conditions, and consequently misses the wave.

Limiting Values.

The limiting value of the sensitivity of a radio receiver is when the ratio of the interfering or extraneous noises to the signal strength approaches 1. As a matter of fact, the limit is approached long before the ratio approaches one in the case of broadcasting; if the ratio is one quarter, the music becomes unpleasant to listen to. Interference, then, is one of the greatest disadvantages that broadcasting has to contend with, and this trouble may be caused by a number of things: Static, power line interference, electrical machinery, radiating receivers. Little is known of the causes producing static, and the subject is, and has been, the subject of study of many scientists. Nearby lightning flashes will, of course, produce violent noises in the receiver, setting up, as they do, a highly damped wave train, which will interfere with any circuit tuned to a point of resonance. Lightning 50 miles or more away will cause similar noises, but of less intensity in the average valve receiver.

Static, however, is often very prevalent on clear nights, when there is no sign of lightning, and this is due to other causes. The atmosphere is not at a uniform zero potential, but at different heights, and in different localities there may be large positive and negative charges; these will cause a continuous electron movement to take place, having the equalisation of the charges as its objective, and this movement produces waves which affect the receiving station. In the same way, when wind blows through rain or clouds, electrification takes place, the rain positive and the wind negative setting up differences of potential, which, if they do not produce lightning, equalise themselves by slower methods, which still produce waves affecting the receiver. Again, when dust is blown about, the potential of the dust clouds is raised, and when such clouds strike an antenna impart to it a true static charge. Sparks over half an inch long have been taken from an antenna at Christchurch during a north-west wind. Evaporation in warm weather is always accompanied by excesses of potential, so that the atmosphere during hot weather is generally in a disturbed state.

Power Line Effects.

Power line interference is very prevalent in many parts of New Zealand, and generally creates effects for which static is blamed. In cities, direct current tramway systems are bad offenders and make the reception of distant stations almost impossible, sparking at the trolley wire and rails, together with sub-station operation give a large variety of interfering noises many of which it is impossible to stop. Broken down insulators on high voltage transmission lines give rise to noises which vary from a crackle to a roar.

Electrical machinery, particularly X-ray, violet ray, diathermy, arc furnaces, battery chargers, and electric ovens, give rise to noises in the receiver which are exceedingly hard to trace. A portion of the annoyance may be overcome by the use of radio frequency chokes at the installation, which prevent oscillations being carried back into the power lines and so radiated.

Enough has been said about the propagation of the wave, its vagaries, and the factors effecting it to show that the transmitting equipment can accept the blame for a very small proportion of the disturbances for which it is often blamed.

The Receiver and Distortion.

We now come to the question of distortion as far as it affects the transmitting station, but before taking up this question we must look again at the average receiver and its operator. Some forms of receivers are supplied with a regeneration control and if the receiving antenna system is poor, or the receiver under powered there will be a tendency for the operator to secure volume by the use of over regeneration with consequent falling off in quality of the reproduction. Then again some audio frequency amplifiers are built for cheapness, rather than quality, and will distort the best of music. Loudspeakers, particularly those of cheap variety will ruin the reproduction of even the best of receivers. Much of the blame that has laid at the door of the broadcasting companies all over the world, alleging poor quality music, can be traced to the receiving apparatus.

Equipment and Personnel.

The transmitting equipment manufactured by such concerns as the Western Electric Company is of course first class throughout and the speech amplifier, modulator and microphone equipment is so designed that if correctly operated it will give remarkably good reproduction—in a good receiver. The routine work of station operator or control room operator has known the light of explanation to some extent in the pages of numerous radio magazines. The public knows that he twirls a number of knobs and the twirling affects the nature of the transmission to suppositional advantage. That is as much as some station operators know too, But in Europe and America has arisen a new occupation, one that is half-way between the station director and the operator. No definite title has been assigned to this new member of the staff although the term accoustician has been used to some extent in America. The holder of this position must first of all be a musician, and also have a fair knowledge of the technique of broadcasting, his duty is to place the microphone in such a position that the various instruments will be reproduced in the receiver in the most natural manner. He is the judge of the quality of the programme, and operation of the speech amplifier control board, should be under his control, rather than that of an operator who knows little of music, and merely follows the movement of a pointer. Given good transmitting equipment then the responsibility of getting good reproduction in the receiver loudspeaker rests with those who see to the placing of the microphone. Years ago it was a common thing for the operator or studio director to wait until the members of the orchestra had taken up their positions and then place the microphone down in any position he fancied. The consequence was that sometimes the big drum drowned all other instruments; at other times it was the cornet, or the saxophone.

The problems of broadcasting are many, the points which have been touched upon in this article cover only a few technical problems which it is hoped will be solved in due time.

HUGE RADIO AUDIENCE

There are 6,500,000 radio receivers in operation throughout the United States to-day, compared with 60,000 in 1922, and the audience listening in to-day is about 26,000,000, as against 75,000 auditors in 1922, according to a survey made by "Radio Retailing" from sources said to be as authentic and accurate as it is possible to obtain. The large increase in the audience is attributed to the fact that loud-speakers are generally used to-day, instead of headphones, so that the entire family can enjoy the etherial entertainment.

Money spent in the United States in the purchase of radio sets and accessories during 1926 is estimated at 506,000,000 dollars (£101,200,000) as compared with 60,000 dollars (£12,000) spent in 1922. The total expenditure for the five-year period from 1922 to 1926, inclusive of sets and accessories, is placed at 1,490,000,000 dollars (£300,000,000, approximately).

GLASS FOR INSULATION

Glass has come into high favour as an insulator at broadcast station KDKA, Pittsburgh, U.S.A., where it insulates the heavy copper bands of the transmitter inductance-coil; brass-tipped glass knobs support various condensers on the panel boards, and glass-air insulation has replaced through-the-wall types. The glass-air insulator consists of drilled bell-jars placed on both sides of a circular aperture in the window glass. By bolting the bells together, with the bolt centring in the aperture and the bells separated from the window glass by rubber gaskets, an effectively insulated binding post is obtained.